ADVANCED TELEVISION SERVICING TECHNIQUES

by

RADIO · ELECTRONICS · TELEVISION · MANUFACTURERS · ASSOCIATION

RADIO-ELECTRONICS-TELEVISION RETMA EST. 1924 MANUFACTURERS ASSOCIATION

PILOT TRAINING COURSE · TEACHING STAFF

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PREFACE

This book was prepared especially for practicing television technicians. It is intended to teach the technician a systematic, organized, industry-approved troubleshooting procedure utilizing the most efficient techniques and the latest test instruments.

It is a practical book detailing recent tv receiver trends and developments and is written in simple, easy-to-understand language. Throughout, emphasis is placed on understanding the purpose and contribution of each section of the tv receiver. Symptoms of troubles arising from defects in each section of the receiver are highlighted and proper procedures to find these troubles are explained. The reader is referred to the Appendix for picture tube patterns illustrating receiver defects, as an aid in diagnosing troubles.

This text represents another step forward by the Radio-Electronics-Television Manufacturers Association in their efforts to improve the TV Service Industry by increasing the technical skill and proficiency of technicians.

In 1953 the authors were selected by RETMA to develop and "prove" by actual instruction, a basic course of study for upgrading practicing tv technicians, and to furnish trade and vocational schools throughout the country with the "know how" to implement this program in their communities. With the full participation of the industry, a tv laboratory completely equipped with the latest test equipment of the leading tv test instrument manufacturers was set up at the New York Trade School, New York City. Over twenty tv manufacturers made their receivers available for research and study.

The material in this text was developed and tested at the New York Trade School. Two pilot classes successfully completed the course of study. The authors' notes, on which this text was based, were used as text materials. This is the text which will be used by all schools adopting the industry-approved course.

The authors wish to express their appreciation to the members of the RETMA Service Committee and Local Advisory Committee for their inspiration and guidance and to the New York Trade School for making their full facilities available for this project.

New York, N. Y.
June, 1954

Paul B. Zbar
Sidney Schildkraut

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A general expression of thanks is accorded all members of the RETMA who have made contributions of equipment, parts accessories and funds to permit the establishment and implementation of the RETMA Pilot TV Training Program.

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CHAPTER 1. INTRODUCTION

I. PURPOSE AND OBJECTIVES OF COURSE

1. History of RETMA Pilot TV Training Course. Recognizing that the television industry is still experiencing "growing pains" and that design "dreams" of today become a reality tomorrow, the RETMA Board of Directors approved a recommendation of the RETMA Service Committee to develop a training program to meet industry needs by keeping TV service technicians abreast of new developments and ever-changing techniques. To carry out this program, the RETMA authorized the creation of a pilot school at the New York Trade School, New York, N. Y.

This, the first course developed, is aimed at upgrading TV technicians by instruction in advanced servicing techniques, utilizing the most modern test equipment, and working on the latest model TV receivers.

2. Training Course Objectives. The objectives of this course are:

a. To increase the technical skill and proficiency of practicing technicians so that they can provide better TV service to the community.

b. To keep practicing technicians abreast of new developments in the field.

c. To teach practicing technicians the principles and practices of, and benefits from, good customer relations.

d. To inculcate in the technician standards of ethics conducive to the welfare of the industry.

II. TROUBLESHOOTING THE TV RECEIVER

A. Review of the Basic TV Receiver

1. TV System. The basic TV system today is the same as the TV system of 1945 and the functions of its sections are the same. However, engineering developments of the last eight years have added refinements to the receiver which have greatly improved its quality and stability. Mass production and quality control know-how have brought down the cost of the average receiver so that homes of every economic level may now own one. There are over 28 million TV receivers in American homes today. The next five years may see the production and distribution of 40 million more.

All this poses a great challenge to radio and TV service technicians. Millions of receivers will, and do, require maintenance. The health of the whole TV industry depends on the ability of the servicemen to meet these maintenance problems efficiently and honestly.

It is toward a more efficient and prosperous service industry that the upgrading effort of this course is directed.

2. Block Diagram of the TV Receiver

a. Intercarrier Sound System. Figure 1-1 is a block diagram of a TV receiver using the intercarrier sound system. There are two types of receivers in use today. The first, and one most universally manufactured receiver, is that using the intercarrier sound system. In this type of receiver, the sound i-f (always 4.5 mc) is taken from the second detector or video amplifier and is then fed to the f-m i-f amplifier.

b. Dual-Channel Sound System. The second, or split-sound, type is one which employs separate sound and video channels. Here, the sound i-f is usually taken from the output of the mixer and fed to the f-m i-f amplifiers. The sound and video circuits of the original RCA 630 are typical of separate sound and video channels.

c. Sections of TV Receiver. The dotted lines in Fig. 1-1 enclose seven separate major sections of the TV receiver. Each of these sections makes a unique contribution to the picture and sound of TV reception. These sections have been designated as (1) front end; (2) video section; (3) sound section; (4) sweep section; (5) sync section; (6) high-voltage section; and (7) low-voltage section.

3. Signal Path in TV Receiver

a. Front-End Tuner. The function of the front end is to select the channel to be viewed and to amplify and convert the channel sound and picture carrier frequencies to lower frequencies; that is, the intermediate frequencies (i-f). As may be seen from Fig. 1-1, the front end consists of the r-f amplifier, the local oscillator, and the mixer.

In operation, we see that the incoming signal is picked up by the antenna and directed to the r-f amplifier, V1. V1 amplifies the incoming signal whose amplitude may vary from 25 microvolts to a much higher value, depending on the location of the receiver and antenna. The amplified signal is then coupled to the mixer stage, V2.

The incoming r-f signal really consists of two carrier signals, the amplitude-modulated (a-m) video carrier and the frequency-modulated (f-m) sound carrier. It is these carrier signals and their accompanying sidebands which contain the video and sound information amplified by V1.

The output of the local oscillator, V3, beats with the r-f signals in the mixer stage, V2, and, in addition to the incoming signal frequencies, new fre-

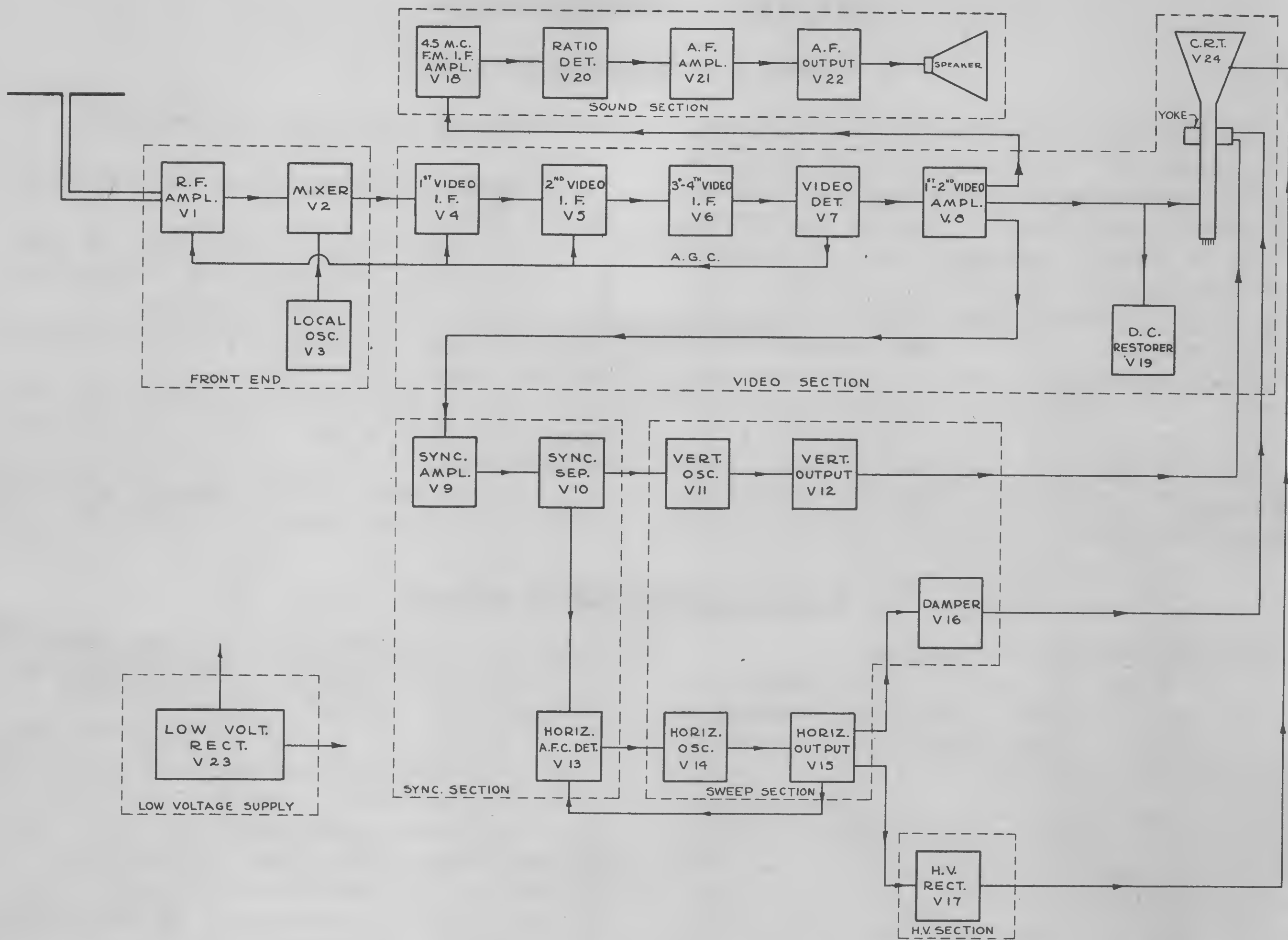


Fig. 1-1. TV receiver block diagram.

quencies are created. These are the difference between the carriers and local oscillator frequencies, in the sum and harmonic combinations. The output of the mixer is tuned to select only the difference frequencies — which are then passed on to the i-f amplifiers of the video section.

b. Video Section. The function of the video section is to detect and amplify the video i-f signals. The resultant video signal is amplified and made to intensity-modulate the electron beam of the CRT. As may be seen from Fig. 1-1, the video section consists of the video i-f amplifiers, video detector, video amplifier, agc, and CRT. In the intercarrier system, both video and sound i-f's are amplified by common i-f amplifiers (V4, V5, and V6). Most receivers use three or four cascaded i-f amplifiers which build up the signal before detection or demodulation takes place in the second detector V7.

The output of the second detector is the composite video signal and a new f-m i-f carrier. The video signal, whose amplitude at the output of the second detector may vary from ½v to 6v, is amplified by one or two video amplifiers and applied to the control grid or cathode of the CRT. Thus, the electron beam of the CRT is intensity-modulated by the composite video signal. This video signal varies in amplitude in accordance with the light intensity of the picture elements of the sequentially scanned picture at the TV studio. It also contains the blanking and sync pulses.

V19, the d-c restorer, acts as an automatic brightness control and maintains the proper bias on the CRT under varying conditions of signal output.

In the TV system employing intercarrier sound, the sound i-f accompanies the video i-f signal and is amplified by the common i-f amplifiers. After detection has taken place in the video detector, a new sound i-f carrier is created. This is 4.5 mc and is the constant difference between the sound and picture carriers of a TV channel. This 4.5-mc carrier is frequency-modulated, as was the original sound carrier, and thus contains the sound intelligence. It is fed to the f-m i-f amplifiers of the sound section.

c. Sound Section. The function of the sound section is to amplify and demodulate the sound i-f signals. The resultant audio signal is amplified and

activates the loudspeaker. The sound section consists of the f-m i-f amplifier, f-m detector, a-f amplifiers, and speaker.

In operation (see Fig. 1-1), the 4.5-mc f-m sound signal is separated from the video signal at the output of the video amplifier, V8, and is fed to V18, the f-m i-f amplifier. This tube is sometimes referred to as the *driver.* Its amplified output goes to the f-m detector, V20, which is usually a ratio detector. The demodulated audio signal from V20 is amplified by V21, the a-f voltage amplifier; then by V22, the a-f power amplifier. This audio signal now activates the speaker and sound is reproduced.

d. Sweep Section. The sweep circuits generate the vertical and horizontal sweep currents which deflect the beam properly so that it traces out the raster on the CRT. The sweep section consists of the vertical oscillator and amplifier, horizontal oscillator and amplifier, damper (and their associated output circuits), and deflection yoke.

V11 (the vertical) and V14 (the horizontal) oscillators generate the deflection voltages at the proper frequencies of 60 cps and 15,750 cps, respectively. They are free-running, and are usually relaxation oscillators. The output circuits of these oscillators contain the shaping networks that determine the waveshape (whether it be trapezoidal or sawtooth) required to insure linear deflection of the electron beam.

The output of each oscillator is fed to its respective amplifier; V12 is the vertical, and V15 is the horizontal amplifier. Both are power amplifiers and are coupled either inductively or directly to their respective windings on the deflection yoke which is mounted on the neck of the CRT. The resultant sweep currents flowing through the windings of the yoke set up linearly changing magnetic fields. The interaction of the magnetic field about the electron beam with these magnetic fields determines the point where the CRT beam strikes the phosphor on the screen and lights it up. The intensity of light given off by the CRT screen at any one point depends on the amplitude and polarity of the intensity-modulating video signal applied to the CRT at that instant of time.

V16 is the damper tube. This tube is wired across the horizontal output transformer secondary and serves to damp out oscillations in this circuit. It also supplies the boost voltage fed to the horizontal output tube, V15. Its action also supplies sweep current to the horizontal deflection coils at the start of the trace.

e. Sync Section. The function of the sync section is to *separate the vertical and horizontal sync pulses from the composite video signal, and feed these pulses directly or indirectly to their respective deflection oscillators. The sync pulses cause the deflection oscillators to fire at the proper frequency and phase, so that the CRT is being scanned at the same rate as the camera tube at the transmitter, and in the same relative position.* The sync section consists of the sync amplifier, sync separator (or clipper), and horizontal afc detector.

In operation, the composite video signal at the output of the video amplifier, V8, contains the video signal and the blanking and synchronizing pulses. This total signal is routed to the sync amplifier, V9, where it is amplified. The design of this circuit usually provides some clipping of the video signal. The signal then goes to V10, the sync separator. This is a limiter circuit which removes the video and blanking signal and leaves the vertical and horizontal sync pulses.

The vertical sync pulses are separated from the horizontal sync pulses by the integrating network or the low-pass filter. These vertical sync pulses now lock the vertical oscillator in proper frequency and phase.

The horizontal sync pulses are fed to V13, the afc detector. This frequency, or phase, detector compares the frequency of the horizontal sync pulses with the frequency of the horizontal deflection voltage coming from V15, the horizontal output tube. If the two signals differ in frequency, the afc detector generates a d-c correction voltage which is applied to the horizontal oscillator and brings it back to proper frequency.

f. High-Voltage Section. The function of this section is *to generate the high voltage required to accelerate the electron beam so that it will have sufficient energy on striking the CRT to cause it to fluoresce brightly.* The high-voltage section consists of the horizontal output tube, flyback transformer, and high-voltage rectifier.

In operation, the high-voltage circuit receives its excitation from the horizontal output tube, V15. The horizontal output transformer also serves as the high-voltage transformer. An autotransformer winding applies high a-c voltage pulses (15,750 cps) to the plate of the high-voltage rectifier, V17. V17 rectifies these pulses, and the resultant d-c voltage is applied to the accelerating anode of the CRT. The d-c voltage varies with the requirements set by the size of the CRT. A 21-in. CRT uses about 13 kv.

g. Low-Voltage Section. The function of the low-voltage section is *to supply the plate, screen, and filament voltages required by the tubes of the TV receiver.* The low-voltage section consists of the low-voltage rectifier, V23, and its associated input circuit and output filter network.

In operation, many receivers use a power transformer which steps up the input 117-v ac. This volt-

age is applied to the rectifier, V23, which rectifies this ac and converts it into pulsating dc. This is then smoothed out by the action of the filter network, and the filtered dc is now available for the plate, screen grid, and bias requirements of the receiver. A secondary step-down winding on the power transformer supplies the required filament voltage (usually 6.3v ac) to heat the filaments of the tubes of the receiver. Some receivers do not use power transformers. In this case the input 117-v ac is usually converted into a filtered d-c voltage by a voltage doubler or tripler. Filament voltage is supplied either by a separate filament transformer or by a series-parallel filament hookup which utilizes the line voltage. This type of power supply usually uses selenium rectifiers instead of vacuum-tube rectifiers.

4. EFFECTS OF DEFECTIVE SECTION ON RECEIVER OPERATION. In most cases, readily identifiable symptoms indicate the section of the receiver that is causing defective operation. Sometimes, multiple defects may lead to troubles more difficult to analyze and isolate.

In this section we will review the general symptoms which would lead us to suspect a specific section of the receiver. It is to be noted, however, that similar symptoms may be due to trouble in one of several sections. We will identify these defects in each section in terms of the three indicators of good TV receiver operation, which are: picture, sound, and raster.

a. Front End. The front end is common to the video and sound circuits. Trouble in the front end will therefore affect both picture information and sound but will not affect the raster. The following typical symptoms may be attributed to trouble in this section:

No picture, no sound, raster OK.
Snowy picture, weak sound, raster OK.
Picture and sound appear on some channels, but not on others.
Weak picture and sound, raster OK.

b. Video Section. Refer to Fig. 1-1. It is evident that the video section from the first video i-f amplifier through the video detector is common to both picture and sound circuits. Hence, troubles in these common circuits will affect both picture and sound. Beyond the sound take-off point, however, the sound and picture signals take different paths. The following typical tymptoms may be attributed to troubles in this section:

No picture, no sound, raster OK.
Weak picture and sound, raster OK.
Smearing, horizontal pulling.
Buzz in sound, dark picture.
Hum in picture, hum in sound.
Hazy picture, sound OK.
No picture, sound OK, raster OK.

c. Sound Section. The 4.5-mc f-m i-f signal enters the sound section at V18. Troubles in this section normally will affect only sound. Some typical symptoms which indicate troubles in this section are:

No sound, picture OK.
Weak sound, picture OK.
Distorted sound, picture OK.
Buzz in sound, picture OK.
Hum in sound, picture OK.

d. Sweep Section. There are two subsections in the deflection circuits, the vertical and horizontal sweep circuits. Troubles in either will affect the raster. Thus, defects in the vertical circuits affect the raster vertically; whereas, defects in the horizontal circuits will affect the raster horizontally and may also affect the high-voltage supply. The following typical symptoms may be attributed to troubles in this section:

Bright horizontal line on screen, no raster, sound OK.
Insufficient height or width, sound and picture OK.
Picture rolling vertically, holds horizontally; sound OK.
No raster, sound OK.
Keystoned (trapezoidal) raster, sound and picture OK.
Picture off-center, left or right, up or down; sound OK.
Vertical or horizontal foldover, sound OK.

e. Sync Section. Defects in the sync circuits common to both vertical and horizontal oscillators will normally affect the synchronization of both. After inter-sync separation has taken place, loss of vertical and horizontal synchronization alone may be affected, depending on where the trouble is. The following typical symptoms may be attributed to troubles in this section:

Picture information is scrambled, dark diagonal streaks are evident; sound OK.
Picture rolls vertically but holds horizontally, sound OK.
Picture cannot be locked in horizontally but holds vertically, sound OK.
Picture split in center vertically with black bar in center, sound OK.

f. High-Voltage Section. The high-voltage section gets its excitation from the horizontal output tube. Troubles in this section will affect the raster. Some typical symptoms of troubles in this section are:

No raster, sound OK.
Very dim raster, sound OK.
Excessive raster height and width, with raster out of focus; sound OK.

g. Low-Voltage Section. The low-voltage supply is common to all the circuits of the TV receiver.

Hence, troubles here will be evidenced by malfunctioning in any or all sections. Some typical symptoms of troubles in this section follow.

No sound, no raster, tubes light.

No sound, no raster, tubes do not light.

Hum in sound and/or in picture.

Raster too small, sound and picture seem OK.

Dark vertical bars on left side of picture, buzz in sound.

B. General Troubleshooting Procedure

1. Basic Troubleshooting Assumption. In troubleshooting a defective receiver we assume that there is just one trouble causing faulty or defective reception. We then try to locate that one trouble by using an organized troubleshooting procedure. It may be that one defective part may have ruined one or several other parts when it failed. However, our procedure is still the same. We still seek out one source of trouble. When that has been found, the receiver trouble will usually clear up. If it does not, we continue seeking the second possible source of trouble, then the third, etc.

2. Isolating Defective Section

a. Use of Service Manuals. The technician should review the service manual for the defective receiver, so that he will become familiar with its physical layout and electrical characteristics.

b. Screen and Sound Indications. By observing the indications on the screen and listening to the sound from the speaker, we form a tentative conclusion as to the defective section. Simple troubles are easily classifiable (see "Effects of Defective Section on Receiver Operation") and the offending section identified.

c. Observation and Manipulation of Controls. A logical procedure to follow in identifying defective sections is:

Inspect the suspected defective section for obvious troubles, such as unlit tubes, open connections, and overheating. Burned-out transformers and resistors have a characteristic smell. Arcing may be identified by a hissing or popping sound. If a defective part is thus found, find out the reason for its failure before replacing it.

Adjust the controls that may affect the operation of the suspected section. If this does not clear up the trouble, then check the tubes.

Replace the tubes, one at a time, in the suspected section with known good tubes. About 60 to 70 per cent of all receiver troubles are due to defective tubes.

d. Tests and Test Equipment Used to Isolate Defective Section. If the trouble has not been found yet, the proper test equipment must be used to examine the operation of the suspected section. *The purpose of using test equipment at this point is to determine whether the suspected section actually is defective.*

3. Test Equipment Used to Isolate Defective Stage. When we have determined that a section is defective, the same test equipment that was used to isolate the defective section may be used to isolate the trouble to a specific stage in that section. This involves the use of the test equipment in a signal tracing or signal substitution process. The signal flow is traced to the point where it ceases or where it becomes abnormal. We identify a defective stage as one which receives a normal signal in its input, but which produces an abnormal signal in its output.

4. Isolating Defective Part. Tests and test equipment are required to isolate a defective part. After the defective stage has been isolated, a VOM or VTVM is used to check voltages and resistances in this stage. These are then compared with the manufacturer's ratings as described in the service manual for the particular receiver. This comparison will bring out differences between observed and rated characteristics. The technician's understanding of circuitry will then make it possible for him to analyze the differences and find the defective part which gave rise to these differences.

The defective part can be tested to verify the correctness of the diagnosis before it is replaced.

5. Correcting Defect

a. Part Replacement Requirements. Each part in a TV receiver must meet certain electrical and physical specifications if it is to serve its function properly. The technician must get an exact or equivalent replacement.

b. Replacement Techniques. Lead dress and dress of parts is critical in certain sections of the receiver. Otherwise, oscillation, instability, or changed characteristics may occur.

6. Additional Preventive Maintenance. Correcting the defect that resulted in the service call is the first order of business of the technician. However, once that is completed, the technician should correct those other minor defects he may have noticed while troubleshooting the receiver. For example:

a. Replace burned-out pilot lights.

b. Fix frayed or broken antenna leads and secure them properly to the antenna strip.

c. Test the tubes in any section of the receiver that appears to be operating at reduced sensitivity, and replace weak or border-line tubes.

d. Tighten loose nuts and bolts.

e. Check evidence of arcing.

f. Adjust controls where necessary.

CHAPTER 2. TV TEST EQUIPMENT

The TV technician must understand the operation and use of his test instruments, because modern servicing of TV receivers requires extensive application of test equipment. This section explains how individual TV test instruments work and discusses characteristics of the instrument important in TV servicing. Applications of the instrument are presented in the text devoted to troubleshooting each of the sections of a TV receiver.

This discussion must remain fairly general. It must be emphasized that, in order to get the most out of the equipment he now has or will purchase in the future, the technician should carefully read the manufacturer's instructions and follow the procedures recommended. Too frequently, a piece of test equipment sits on the shelf unused because the technician does not take the time to learn its operation.

A. Oscilloscope

1. Why It Is Used. The oscilloscope may be used in servicing every section of the TV receiver. Specifically, it serves the following purposes:

a. Indicator in sweep alignment of front end and i-f amplifiers and TV detector, f-m i-f amplifiers, and detector.

b. Signal-tracing the video amplifiers and/or audio amplifiers and analyzing the composite video signal.

c. Signal-tracing the sweep and sync circuits.

d. Signal-tracing the i-f's, using a demodulation probe.

e. Checking ripple in power supply circuits.

f. A-C VOM in checking peak-to-peak (PP) amplitude of sine or nonsinusoidal waveforms.

g. Indicator in checking frequency response of video and/or audio amplifiers.

h. Frequency measurements in checking unknown frequency of a signal by comparison or heterodyning.

i. D-C voltmeter, where direct coupling is provided.

2. Block Diagram. The simplified block diagram in Fig. 2-1 illustrates certain general principles of the oscilloscope. Every manufacturer's design varies somewhat from other designs. However, most servicing oscilloscopes (scopes) are basically similar.

The technician must know his oscilloscope to make the best use of it. His familiarity with the more complex TV circuits should make understanding of an oscilloscope a fairly simple process. The following paragraphs give a brief discussion of its operation.

The heart of the cathode-ray oscilloscope is the cathode-ray tube indicator (refer to Fig. 2-1). These are similar to the CRT's used for TV except that they are smaller (most use a 5-in. tube). Also, most service oscilloscopes use electrostatically deflected cathode-ray tubes.

The CRT shows the waveform of the signal to be viewed. This signal may be too small to be seen if applied directly to the CRT. Hence, it is amplified by the vertical or signal amplifiers before being applied to the vertical deflection plates of the CRT. The signal thus applied to the vertical deflection plates will deflect the beam vertically.

If no voltage were applied to the horizontal deflection plates, we would simply get an up and down trace and we could not tell what the video signal looked like. To overcome this, and to make it possible for the scope to trace out or graph the signal, a linearly changing (timebase) deflection voltage is applied to the horizontal deflection plate(s). This sawtooth voltage is generated by the timebase (sweep) oscillator and is amplified by the sweep amplifier and then applied to the horizontal deflection plates. This sweep oscillator is either a thyratron oscillator or a hard-tube sawtooth oscillator, such as the multivibrator. Single-ended deflection, with the deflection signal applied to only one vertical and one horizontal deflection plate, may be used. Many oscilloscopes use push-pull deflection for greater deflection sensitivity and to reduce distortion due to unbalance across the deflection plates.

TV waveforms are periodic waveforms; that is, they recur at a specific frequency. To see a complete waveform or several waveforms stationary on the scope screen, it is essential that the sweep frequency be equal to, or be a submultiple of, the waveform frequency. Thus, to see a single 60-cps sine wave stationary on the screen, the scope sweep frequency must be 60 cps. To see two cycles of a 60-cps sine wave, the scope sweep frequency must be one-half of 60, or 30 cps. To see five cycles of a 1,000-cps waveform, the sweep speed or frequency must be one-fifth of 1,000 cps, etc. It is therefore necessary to provide an oscillator whose frequency is adjustable. This is accomplished by a switch (coarse frequency) and a control (fine frequency).

However, it would still be difficult to set the sweep frequency just right to maintain a stationary pattern. Therefore, a synchronizing circuit is provided which locks the sweep oscillator to the signal frequency. This synchronizing circuit may contain a synchronizing amplifier to boost the sync signal to a point where it will be effective in locking the sweep oscillator.

A sync control (attenuator) sets the level of sync signal which is coupled to the sweep oscillator.

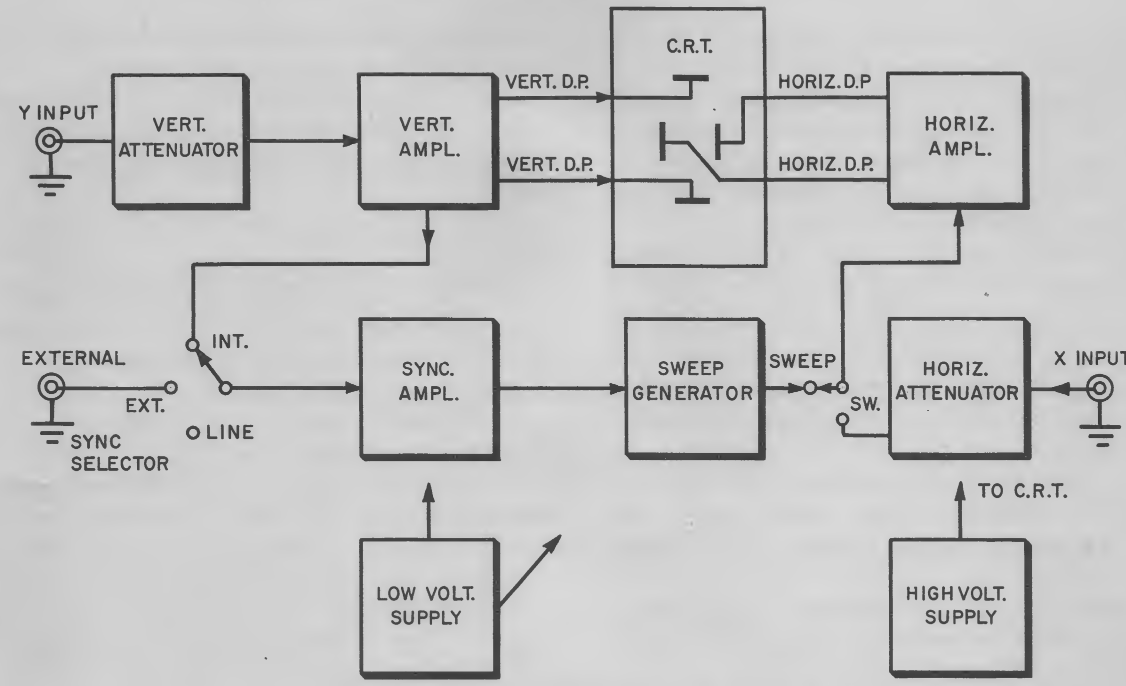


Fig. 2-1. Oscilloscope simplified block diagram.

Most oscilloscopes provide a sync selector switch. This is usually a multiposition switch for selecting either line voltage or the signal being applied to the vertical input of the scope, or any other external synchronizing signal. In many TV applications internal sync is used.

The low-voltage power supply provides filament, plate, screen, and bias voltages for the tubes in the scope. The high-voltage supply provides accelerating and other potentials for the CRT.

In summary it should be noted that *the oscilloscope is like a TV set in these respects*:

a. It uses a CRT as an indicator.

b. It generates horizontal deflection voltages which are applied to the CRT.

c. It contains a high-voltage supply for CRT requirements.

d. It contains sync circuits to lock the sweep so that the pattern is stationary.

e. It contains signal amplifiers (vertical amplifier).

An oscilloscope differs from a TV receiver in these respects:

a. A waveform, rather than a picture, is seen on the screen.

b. In the scope the signal is applied to the vertical deflection plates. In the TV receiver the video signal is applied to the grid or cathode of a CRT and intensity-modulates the beam.

c. The scope automatically plots the graph of the waveform to be seen. The sweep of the scope is comparable to the timebase, or *X* axis, of a graph. The signal under observation is plotted on the vertical, or *Y*, axis. Some scopes incorporate a *Z* axis. This is a connection to the grid or cathode of the CRT for intensity-modulation purposes. This is for special applications and is rarely used in TV servicing.

d. A scope does not have frequency selective circuits, such as front end and i-f amplifiers found in a TV set.

3. Oscilloscope Characteristics. There are certain scope characteristics which are important in determining its usefulness for TV servicing. These are discussed below.

a. Frequency Response. The vertical, or signal, amplifier of a scope must have a wide frequency response to pass the TV sweep, sync, and blanking pulses, and the video waveforms without significant distortion. The reason for this is that periodic nonsinusoidal pulses, such as sync pulses or sweep voltages, are composed of a fundamental and many harmonics. For example, a theoretically perfect square wave has an infinite number of odd harmonics. If the response of the vertical amplifier is narrow, it will not pass the fundamental and harmonic components in their proper amplitudes and phase relationships, but will distort them, and a square wave will not be seen.

The sync and blanking pulses of the composite TV video signal, which are essentially rectangular pulses, must pass through the scope vertical amplifier without distortion and appear as they do in a TV receiver. Thus, a scope with a broad vertical amplifier will not introduce distortion when checking waveforms, and proper comparison can then be made with the manufacturer's specified waveforms.

b. Sensitivity. Sensitivity is related to the deflection sensitivity of the CRT and to the gain of the vertical amplifiers. It is usually rated in millivolts per inch. For example, a vertical sensitivity of 30 mv/in. means that an input signal of 30 mv, applied with vertical gain set to maximum, will give a 1-in. vertical deflection on the scope.

To handle large signals, an attenuator is incorporated in the scope. This can be either a combination step and continuous type or just a continuous attenuator. Where step attenuators are used, they are usually calibrated. If a continuous attenuator is used, it is possible that the frequency response will change with the setting.

Calibrated attenuators can be used to give approximate peak a-c readings. Where exact readings are required, external or internal voltage calibrators are used.

c. Input Impedance. The input impedance rating of any instrument states the amount of impedance introduced by an instrument across a circuit to which it is applied.

In a scope, the input impedance is usually expressed in terms of a resistance paralleled by a capacitance. Thus, a scope whose input impedance is 2 meg 50 mmf loads the circuit down by a parallel combination of these values.

Since the input impedance contains a capacitance, the impedance is a function of the frequency of the signal being viewed. Hence, the scope will tend to load high-frequency circuits more than it will low-frequency circuits. Of course, the size of the load across which the waveform is being viewed will also affect the extent of loading. Across a low resistive load, the scope will not have as much loading effect as across a high resistive load.

It is therefore important to keep the following rule in mind when observing waveforms with high-frequency components.

Place the scope leads across a low-impedance circuit if possible, in order to reduce the effects of loading on the circuit.

This rule should also be observed in viewing periodic nonsinusoidal waveforms such as sweep waveforms and sync pulses.

In this connection it should be mentioned that special low-capacitance probes have been designed to extend the usefulness of the scope in viewing waveforms with high-frequency components.

d. Sweep Frequency Range. The range of the sweep oscillator of the scope must be sufficient for viewing TV waveforms. For TV servicing it is important to have the range of sweep frequencies extend from about 20 cps for observing the vertical sweep and sync signals to 15,750 cps for observing the horizontal sweep and sync signals. In actual practice the sweep range of oscilloscopes is greater. Hence, the extent of their application is greater.

e. Special Characteristics. Certain special characteristics have been incorporated in the design of some oscilloscopes to extend their usefulness. These include:

- Internal voltage calibrators, or a simple provision for use with an external calibrator.
- Phase-shifting control for sweep alignment to permit back and forward traces to overlap.
- Beam-blanking during retrace.
- D-C amplifiers.
- Triggered sweep (synchroscope).
- Trace expansion.

4. OPERATING CONTROLS. The following paragraphs briefly describe the function of scope controls.

a. Focus is adjusted in conjunction with the intensity control for sharpest trace on scope.

b. Intensity is comparable to brightness control in a TV set. It is set for desired intensity level in conjunction with focus control.

c. Vertical Multiplier or Selector is a step attenuator selector which chooses the constants of a voltage divider operating off the vertical input. In conjunction with the vertical gain control, it sets the level of the signals. The attenuator is calibrated and has a constant multiplier as it is switched from range to range.

d. Vertical Gain is a potentiometer which is continuously variable over each range of the vertical attenuator. It adjusts the level of the signal coupled to the vertical amplifier. In many oscilloscopes a vertical gain control only is used, without a vertical multiplier.

e. Horizontal Gain is the same as vertical gain, except that it controls amplitude of the signal coupled to a horizontal amplifier. It is adjusted on a 5-in. scope to give a sweep width of approximately 4 in., for most applications.

f. Horizontal and Vertical Centering are potentiometers. They control the left and right, up and down positions of the electron beam. They are adjusted for proper location of the pattern.

g. Coarse Frequency is a rotary selector switch which determines the frequency range of the internal sweep oscillator. It is operated in conjunction with the fine frequency, or sweep vernier, control to set sweep at the desired frequency. It sets the frequency-determining time constants in the horizontal oscillator. In certain scopes this control has two extra positions labeled "Hor. Amp." and "Hor. Input." In these two positions an external deflection signal may be fed to the horizontal amplifier or directly to the horizontal deflection plates.

h. Fine Frequency, or Vernier, is a potentiometer. It operates in conjunction with the coarse fre-

quency control and is continuously variable from minimum to maximum over each range. It permits any sweep speed between the coarse steps to be obtained. In practice, it is used to adjust sweep speed so that it easily synchronizes with the signal.

i. Sync Selector is a rotary switch which selects either internal, external, or line sync. On line position it receives a part of the a-c line voltage. On internal position, it receives part of the signal which is being observed. On external position it will lock in the sweep with an external signal applied to the external sync binding post.

j. Sync Amplitude is a potentiometer which varies the level of the sync signal coupled to the vertical oscillator.

The sync amplitude control is set at the lowest level (minimum clockwise) at which it will lock a signal. When the scope is used for frequency measurements, sync amplitude control should be carefully set at absolute minimum; otherwise, false readings will be obtained.

k. "On-Off" is usually a switch associated with the intensity control, or it may be a separate switch for applying power to the receiver.

5. Input Jacks or Binding Posts. The function of these is evident from their title.

a. Vertical Input and ground: for the input signal under test.

b. Horizontal Input and ground: accepts external voltage for the horizontal amplifier or deflection plates.

c. Sync: for external sync.

d. Test Signal: a fraction of line voltage is available at this jack for calibrating the scope as an a-c voltmeter.

e. Intensity Modulation: accepts a signal for the grid or cathode of CRT and intensity-modulates the electron beam by controlling electron density in the beam.

6. Getting Acquainted with Operating Controls of Scope. The student should read and follow the operating instructions in the manual accompanying the oscilloscope so that he may learn its characteristics. A general get-acquainted procedure, which is applicable to all scopes and does not take into account the specific unique features of any particular scope, follows:

a. Turn coarse frequency control to its minimum sweep frequency setting. Set sweep vernier in middle of its range and horizontal gain to middle of its range.

b. Set vertical and horizontal centering controls to middle of their range.

c. Turn sync amplitude control completely counterclockwise (to zero sync).

d. Turn scope on and advance intensity control three-fourths of the way up.

e. Allow scope about 2 min. to warm up, and then adjust intensity and focus controls for sharpest trace and satisfactory brightness.

f. Observe effect on trace of varying vertical and horizontal centering controls, and set these so that the trace is properly centered.

g. Adjust horizontal gain control for satisfactory trace length, about 4 in. on a 5-in. scope.

h. Now connect vertical input cable of the scope to test signal source on scope; or if this is not available, to 6.3-v a-c source. The scope should be grounded to the ground of the voltage source.

i. Adjust vertical selector and vertical gain control until the signal is 2 in. high on scope.

j. Adjust sweep vernier (fine frequency) until there is just one sine wave on the screen — almost stationary.

k. Set sync selector to internal (or line) sync and advance sync amplitude control clockwise until sine wave is stationary.

l. Now, as an exercise, readjust sweep vernier until two sine waves are stationary on the screen; three sine waves; and then four sine waves. It may be necessary to readjust the setting of sync amplitude control to stop any tendency of the signal to drift.

B. Oscilloscope Auxiliaries

1. Low-Capacitance Probe

a. What It is and Why It is Used. Refer to "Input Impedance" of the oscilloscope. A low-capacitance probe extends the usefulness of an oscilloscope by reducing the loading effects of the scope in high-impedance circuits. Essentially, a low-capacitance probe consists of a large resistor (*R* in Fig. 2-2) in parallel with a small capacitor (*C* in Fig. 2-2) in a suitably shielded insulated probe and with proper facilities for connection either to the direct probe of the scope or to the vertical input of the set itself. The impedance of the probe is effectively in series with the input *Z* (a parallel combination of *C* input and *R* input) of the scope. Therefore, the total impedance that the probe and scope present to the circuit is much higher than that of the scope alone.

For example: In the RCA CRO-type WO-88A, the input impedance at the input terminals is 1 meg, shunted by 30 mmf. With the WG-218 direct probe and cable, it is 1 meg, shunted by 75 mmf (due to the capacity of the cable). With the WG-216B low-

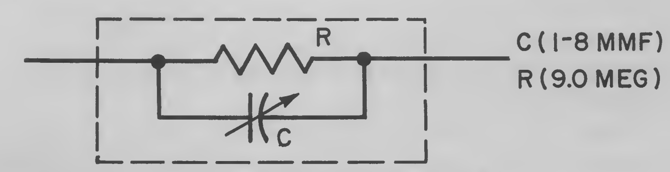


Fig. 2-2. Low-capacitance probe.

capacitance probe, it is 10 meg, shunted by 9.5 mmf.

Reference to Fig. 2-2 indicates that C is variable. It is made variable so that it may be adjusted to the scope and cable. When C is properly adjusted, the broadband response of the scope is unaltered. To accomplish this, the time constant $C \times R$ is made equal to $C_{in} \times R_{in}$ (input Z of scope). It should be noted that addition of a low-capacitance probe reduces the amplitudes of the signal applied to the scope input. In the example cited this is reduced to one-tenth of its original value.

b. When It Is Used. The low-capacitance probe should be used whenever

(1) Measurements are made across high-impedance circuits.

(2) Measurements are made of waveforms containing high-frequency components.

(3) Measurements are made in frequency critical circuits. For example, the loading effect of a direct probe and cable across the tank circuit of a stabilized horizontal oscillator may change the frequency of the horizontal oscillator sufficiently to cause it to lose synchronization. This is avoided by use of a low-capacitance probe.

2. Demodulation Probe. This probe is also known by other names, such as crystal-detector probe, crystal-diode probe, r-f probe, or detector probe. Its purpose is to detect the amplitude-modulation of an r-f or i-f carrier, just as the video detector does in a TV receiver. It is used in r-f and i-f alignment for detecting response curves of stages prior to the video detector. It is also used in signal-tracing the i-f amplifiers and for tracing buzz in sound i-f circuits.

Figure 2-3 is a schematic diagram of a demodulation probe. A germanium diode, Y, is used as the rectifier. The R and C constants have been chosen to give r-f filtering. Thus, only the envelope of modulation is left at the output, which is then applied to the vertical input of the oscilloscope.

The probe illustrated is a high-impedance probe with an input capacitance of 2.25 mmf. Hence, it may be used in frequency-critical circuits without serious detuning of these circuits. Other probes with different constants and lower input impedance may act to detune such circuits.

When the probe is used with an oscilloscope, and when a sweep generator is employed to sweep the picture or sound i-f amplifiers of a TV receiver, it is possible to observe the response characteristics of individual amplifier stages. With this combination of equipment, the technician may observe the response curves of picture and sound i-f amplifiers, video amplifiers, and tuners.

When the probe is used for signal-tracing the video i-f stages of a TV receiver, a reasonable likeness of the composite video signal appears on the scope as the probe is moved from grid to plate of the i-f amplifiers through which the modulated i-f signal is passing. An inoperative stage is indicated at the point where no signal is seen.

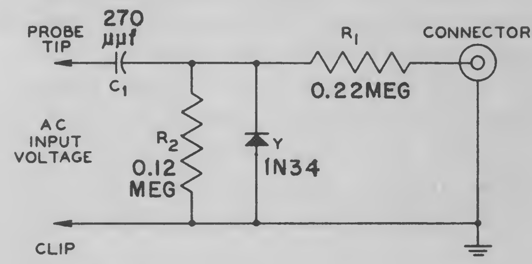


Fig. 2-3. Demodulation probe. *Courtesy RCA.*

It is well to note, however, that the amplitude of the waveform on the scope depends on the sensitivity of the scope and the strength of the signal detected. Thus, nothing may be seen in the stages of the front end or grid of the first i-f unless the sensitivity of the oscilloscope is very high.

One other caution: The probe is not designed as a wideband video detector. Hence, it will distort high-frequency components of the video signal, such as horizontal sync pulses. It is useful merely as an indicating device to follow the progress of the signal.

The demodulation probe may also be used with a VTVM on d-c position to give readings proportional to the r-f carrier.

3. Oscilloscope Voltage Calibrator

a. Why It Is Used. Service manuals contain information about waveshapes and PP voltage amplitudes of these waveforms at check points in the TV receiver.

In servicing a TV receiver it is desirable, therefore, to know both the appearance of the waveform and its amplitude. It is possible to calibrate the scope so that it will give a-c PP voltage readings. An oscilloscope calibrator is used for this purpose.

Some oscilloscopes are designed with built-in calibrators. Some have available a test signal at a binding post on the front panel. Where an internal means is not provided, some external means of calibration must be used.

b. How an External Calibrator Is Used. Suppose we wish to measure the PP amplitude of the output of the vertical oscillator in a TV receiver. The scope controls are adjusted for proper viewing and the receiver vertical oscillator output signal is applied to the vertical input terminals of the scope. The vertical gain control of the scope is adjusted so that the input signal occupies, say, four squares on the graph chart on the screen. The scope horizontal sweep may be collapsed so that there is only vertical deflection (four squares) on the scope, due to the

signal voltage. At this point the setting of the oscilloscope vertical gain control must not be changed. Now the receiver signal is removed and the calibrating voltage applied to the vertical input of the scope. The calibrator output control is varied until the calibration signal also occupies four squares vertically. The amplitude of the voltage is read directly from the calibrator meter or control. This is the desired waveform voltage.

We may say, then, that scope voltage measurements are comparison measurements. The calibrator output is a variable voltage signal, usually a square wave, which is compared with the waveform to be measured. The amplitude is read from meter or panel.

c. Block Diagram of the External Calibrator (Fig. 2-4). The block diagram shows that a regulated power supply furnishes voltage for the sine or square wave generator. The output control sets the amplitude of square wave coupled to the output of the calibrator through the range selector. The range selector is a calibrated attenuator which selects, in several ranges, a predetermined fraction of the sine or square-wave output. A meter or a calibrated dial indicates the output voltage of the calibrator.

The calibrator usually contains a switch for applying the square wave to the video signal for comparison to the oscilloscope. This is accomplished by applying the video signal to the input posts of the calibrator. A switch then connects input to output posts. Output posts of the calibrator are then connected to the vertical input of the scope. This hookup is not recommended in viewing video or sweep waveforms because the calibrator and its associated switch and cable load the circuit where the waveform is being observed.

d. Scope with Built-In Calibrator. A scope with a built-in calibrator simplifies measurements. A switch on the panel of the scope applies either the signal to be measured or the calibrating voltage to the scope vertical amplifier. Again, the comparison method is used. Voltages are read from either a meter or a calibrated dial on the scope panel, or from a calibration chart.

4. Scope Calibration With Known Voltage Source. Calibration of the scope can also be accomplished by applying a known voltage to the vertical input. This can be a test signal on the scope panel or 6.3v rms (18v PP) on a filament line. Thus, if the 18-v PP signal is set up to give one crosshatch square of vertical deflection, then a four-square deflection equals 72v PP (4 x 18).

When the known voltage source is small compared with the signal under test, the vertical step attenuator on the scope can be employed to set off a usable vertical deflection. In this case the oscilloscope is cali-

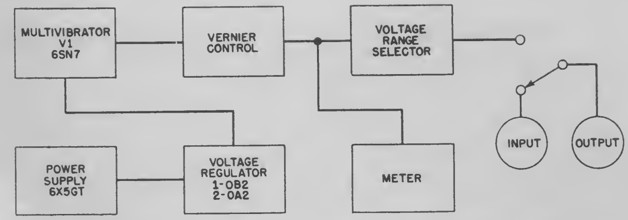


Fig.. 2-4. Block diagram of voltage calibrator. *Courtesy Hickok Electrical Instruments Co.*

brated on the lowest attenuator range. This automatically calibrates the other attenuator ranges, so long as the vertical gain control of the oscilloscope is not varied.

For example, if the calibration voltage is 1v PP and it deflects the waveform two squares, then turning up the step attenuator by a factor of 10 makes two squares equal to 10v, and three squares equal to 15v PP, etc. The general procedure, then, in calibrating the oscilloscope with a known voltage source has been described.

To measure the PP amplitude of an unknown waveform, the technician would then proceed as follows:

Calibrate the oscilloscope so that every minor crosshatch square represents a certain voltage, say 2v PP. Without disturbing the setting of the vertical gain control of the scope, apply the waveform whose amplitude is to be measured to the vertical input of the oscilloscope. Measure the vertical PP amplitude of the observed waveform. Assume the waveform occupies 10 squares. Now multiply this number, 10, by the voltage factor of a square. This is the voltage amplitude of the waveform. In this case, the voltage would be 10 x 2, or 20v.

C. Vacuum Tube Voltmeter

1. General. The VTVM is one of the basic pieces of test equipment — a must for every TV service shop. It utilizes a meter movement in a suitable vacuum-tube circuit to secure measurement of d-c voltage, a-c voltage, and resistance. A high-voltage probe extends its usefulness to include measurement of high voltage. An r-f probe makes it possible to measure high-frequency voltages. The amplitude of the r-f voltage, however, must be large enough to give an indication. The high input impedance of a VTVM makes it possible to use this instrument with a minimum loading of the circuit being measured. Thus, oscillator grid voltage may be measured with a VTVM.

2. VTVM Operation. A function switch sets the VTVM for proper operation as a d-c voltmeter, a-c voltmeter, or ohmmeter. There are usually different leads for each of these functions. The d-c lead is usually shielded and contains a large isolating resistor (1 meg or higher) at the probe tip. The a-c lead is

also shielded, but has no resistor. The leads for measuring resistance are unshielded.

A range selector switch determines the proper operating range for each of the VTVM functions.

The VTVM circuits contain a d'Arsonval type of meter movement. This movement may be in the plate or cathode circuit of a vacuum-tube amplifier. Or it may be placed across a balanced-bridge type of circuit using two vacuum tubes. Many other arrangements are also used.

For a-c measurements a rectifier is used to change the ac into dc. This may be a crystal or vacuum-tube type of rectifier. The resultant d-c voltage is used to control current flow through a vacuum tube where the meter movement is located. VTVM a-c scales are usually calibrated in terms of effective or rms readings. Most VTVM's incorporate a blocking capacitor in the a-c circuit to make it possible to read a-c voltage alone, in circuits containing both dc and ac.

Some manufacturers are now incorporating circuits for measuring peak or peak-to-peak voltages. This feature is useful in measuring voltages in circuits such as the deflection system in a TV receiver, where nonsinusoidal waveforms are developed. The peak-to-peak readings usually are made on a separate selector switch position, or by use of a special probe other than the a-c probe. Such meters contain a separate peak-to-peak scale.

For resistance measurements the unknown resistance is placed in series with a precision resistor in the meter, for that range. This completes the ohmmeter circuit which includes one or two 1.5-v dry cells. By voltage divider action, a proportional voltage appears across the unknown resistor. This is applied to the vacuum tube connected to the meter. The meter scale is calibrated in ohms for the resistance ranges.

3. Operating Controls and Adjustments

a. Function Switch. This has already been discussed. The switch has an a-c position, an ohms position, and two d-c positions. These are plus (+) volts and minus (–) volts. Thus, by throwing the switch to + or to – dc, voltages that are positive or negative with respect to common may be read.

b. Range Switch

(1) *D-C volts*: There are as many as six or seven ranges for d-c and a-c volts. The voltage scales are linear.

(2) *A-C volts*: Most VTVM's contain a separate scale for a-c voltages. The a-c ranges of the VTVM are interpreted in the same manner as the d-c ranges.

(3) *Resistance – ohms*: The resistance scale is nonlinear. The range switch is a multiplier for resistance. In the R x 1 range, the resistance readings are read directly from the scale. In the R x 10 scale, readings are multiplied by 10.

c. Zero Adjust. This control is used to compensate for meter drift. It is adjusted to give zero settings on volts. Its setting may vary on the different settings of the function and range switches.

d. Zero Center. One position of the range switch is for zero center, or the range of the zero adjust is sufficiently wide in most commercial VTVM's so that the meter needle can be set in the center of the scale with zero applied voltage. In this position the meter will measure d-c volts without the need to change the function switch or position of the leads. This is very useful for f-m discriminator alignment.

4. Do's and Dont's in Using VTVM

a. The VTVM should not be used until it has warmed up sufficiently and has become stabilized.

b. In measuring resistance, be certain that power has been removed from the receiver where measurements are to be made.

c. In measuring unknown voltages, set the range selector to its highest range first, and then set it to the indicated range after the first reading. This will prevent damage to the instrument.

d. Most voltage measurements will be made with respect to ground. But, if it is necessary to measure voltage between two points, both of which are above ground, be careful. The ground of the instrument is usually connected to the instrument case. The case would be hot in making measurements other than those with respect to ground. Under this condition, the only voltage isolation is due to the primary and secondary of the instrument transformer; most a-c power systems have one side grounded. A suggested method is to read the voltage at both points and compute it algebraically.

5. High-Voltage Probe. This probe extends the range of the VTVM or VOM on d-c from 1,000v, which is the maximum range on most meters, up to 25,000v and higher. The actual range depends on the size of the multiplier resistor contained in the probe. This makes it possible to measure high-voltages in a TV receiver.

The physical design of the probe insures maximum safety to the technician. Features are included to protect him against accidental contact with the high voltage to be measured. There is also protection against arcing and corona. (See Fig. 2-5.)

High-voltage probes are designed for the specific VTVM with which they are to be used. The manufacturer's instructions specify the range on which the meter must be set and the multiplying factor of the probe.

High-voltage measurements are made at the output of the high-voltage supply only when there is doubt as to the proper functioning of this circuit. If measurement is made with the CRT in the circuit,

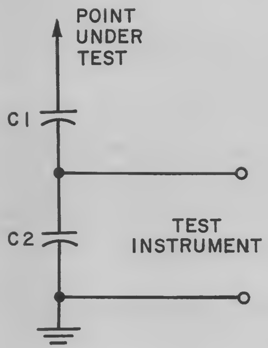


Fig. 2-5. High-voltage probe.

the second anode voltage will be affected by the setting of the brightness control.

The following precautions should be observed in measuring high voltages:

a. Never use a wet or moist probe. Make sure that your hands are dry.

b. Check to see that the probe and lead insulation is not cracked or broken.

c. Put one hand in your pocket. That is the safest way to avoid accidental contact to a ground.

6. R-F PROBE. This probe is similar to the demodulation probe used with an oscilloscope, and in some applications, is actually interchangeable with it.

This probe is used in measuring r-f voltages and also in tracing the r-f or i-f signal through the respective stages in a TV receiver. Thus, with a VTVM and r-f probe, the technician can follow the progress of the r-f or i-f signal in troubleshooting these circuits, just as he did with the oscilloscope and demodulation probe. However, the vertical amplifier of the oscilloscope extends the sensitivity of that instrument beyond the range of the VTVM.

The schematic diagram of the r-f probe is similar to that of Fig. 2-3, but there are many variations. Several types of rectifiers have been used, including miniature diodes and crystals (germanium diodes). Crystals are limited by the maximum voltage which they can withstand — usually up to 20 or 25v. However, this is not a problem in r-f or i-f circuits in which the voltages are well within the rated capabilities of the crystal probe.

The input impedance of the r-f probe must be as high as possible, in order to avoid loading the frequency-sensitive circuits where measurements are being made. The frequency range of r-f probes has been made as high as 1,000 mc.

In using an r-f probe, keep the ground leads very short. Do not clip extension leads to the probe tip, but place the probe tip at the point of measurement.

7. HIGH-VOLTAGE A-C PROBE FOR VTVM OR SCOPE. The high pulse voltages in the output of the horizontal sweep circuit exceed the input voltage ratings of the oscilloscope and the VTVM. A capacitive divider probe can be constructed to extend the a-c ranges of these instruments. Two capacitors in a divider network circuit are used for this purpose. A typical circuit arrangement (Fig. 2-5) uses a small high-voltage capacitance for the input capacitor C1, and a larger low-voltage capacitance for C2. The two capacitors are in series, and the test instrument is in parallel with C2. C1 is connected to the point under test, and C2 is connected to the ground return of the circuit.

a. Construction. In one type of probe a high-voltage rectifier, such as a 1X2A, is used as the input capacitance, C1. This capacitance and its associated wiring is about 1.7 mmf. The rectifier filament is not energized and only its interelectrode capacitance is used. In this case the total capacitance of C2 should be 170 mmf to give a 100 to 1 probe. The total capacitance consists of the sum of the input capacitance of the test instrument, the cable, and any external capacitance which might be added to the circuit.

In the shop a simple substitute capacitor may be easily constructed. Two pieces of high-voltage wire, each 12 in. long, can be intertwined, after stripping the ends, to produce a high-voltage capacitor of approximately 5 mmf. This is done by twisting the two pieces of wire together in the form of two U's, with the open ends of each tied together at opposite ends of the cable. The 6-in. cable thus formed is used in place of C1. (An alligator clip may be attached to one end for easy connection to a high-voltage point). For C2 a capacitor of approximately 500 mmf can be used with a low-impedance scope probe. A smaller value capacitor is used with the scope direct probe or the a-c range on a VTVM.

b. Calibration. The probe can be calibrated by using a known high a-c voltage for a standard, such as that from the secondary of a power transformer. In order to obtain a 100 to 1 relationship, the capacitance values can be changed slightly or a trimmer capacitor can be used across C2. Reducing the length of the twisted cable a little at a time provides an easy method of varying the capacity of C1.

c. Use. The probe can be connected directly to the plate of the high-voltage rectifier, the horizontal output tube, the yoke, or the damper plate. Proper insulation must be provided, and caution must be exercised when checking these high-voltage points.

D. Volt-Ohm Milliammeter (VOM)

The VOM is another must for the service shop. It is a stable instrument which measures voltage (dc and ac), resistance, and current. Most VTVM's do not include the current-measuring function.

The VOM is especially popular with technicians for use in home servicing, because it requires no external source of power. The only power needed is for resistance measurements. This is supplied by one or two flashlight cells contained in the case.

Unlike the VTVM, the VOM contains no vacuum tubes in the meter circuit. It is a meter movement with a suitable arrangement of precision resistors and a switching circuit. In the case of the a-c function, a rectifier is included. There is no blocking capacitor in the a-c input. Hence, if it is necessary to measure a-c voltage at a point also carrying d-c, the *output* function of the meter must be used. If there is no output function, a capacitor (0.01) should be placed in series with the hot lead.

Most VOM's contain a function selector switch for dc, ac, and *output*. Where such a switch is not included, panel jacks are designated for proper function.

In addition, VOM's contain a range switch, whose use is the same as on the VTVM.

The d-c input resistance of the VOM is given by an ohms/volt rating. For TV servicing this should be at least 20,000 ohms/volt. (A 100,000 ohm/volt meter is now commercially available.) This rating means that the input resistance of the meter depends on the range setting. For example, on the 10-v range the input resistance of the 20,000 ohms/volt instrument is 10 x 20,000, or 200,000 ohms. On the 1,000-v range the input resistance is 20 meg.

A VOM on its lower ranges may load circuits under measurement, giving rise to false readings.

The maximum voltage range is usually 1,000v. However, facilities in the form of separate panel jacks are frequently provided for measurements up to 6,000v, both dc and ac.

A meter with a 20,000 ohms/volt rating for dc is usually rated at 1,000 or 5,000 ohms/volt ac.

Many companies now make high-voltage and r-f probes for use with the VOM.

The VOM requires no warm-up time. As with the VTVM, the technician should follow the manufacturer's instructions, to get the most out of this instrument.

E. Tube Testers and CRT Tester

1. Functions. Tube failures represent 60 to 70 percent of all receiver troubles. Intelligent use of a tube tester can reduce servicing time. The objection, often heard, that tube testers will not spot all troubles is true, especially of applications involving the use of a tube as an oscillator. However, with this limitation, the tester has many useful and profitable applications in a modern service shop. They are used:

a. To check the performance of tubes brought into the shop to be tested.

b. To find bad tubes in sets brought in for repair.

c. To spot tubes with problems of leakage, shorts, open filaments, etc. This function often reduces servicing time in sets with difficult repair problems, such as reduced sensitivity.

d. To conduct preventive maintenance checks which involve periodic tests of receiver tubes, so that weak tubes can be spotted and then replaced, thus preventing future receiver failures.

2. How To Use Tube Tester. There are many commercial tube testers on the market. Though they all use similar principles, the design of each is somewhat different. Hence, the only safe procedure in using a tube tester is to follow exactly the manufacturer's instructions.

Make *all* the *tests* listed in the manufacturer's instruction manual for best results.

3. Cathode-Ray Tube Tester. Like the regular tube tester, the CRT tester checks the performance of cathode-ray tubes. Beam current intensity is used as a measure of proportionate screen brightness.

The tester can be used to check the CRT on the bench, in cartons, or directly in the TV set without removing the picture tube from the cabinet. It is therefore a useful portable instrument both in the shop and in the field.

The manufacturer's instructions should be followed carefully in operating this instrument.

F. Crosshatch Generator, or Dot and Bar Generator

1. Function. In the absence of a test pattern, a crosshatch generator can be used for adjusting linearity, size, and hold controls in both the vertical and horizontal sweep circuits. Sync, focusing, and centering adjustments can also be made with this type of generator. A crosshatch generator also has many other uses as a TV signal substitute instrument.

2. Types of Crosshatch or Dot and Bar Generators. There are different types of crosshatch or dot and bar generators available commercially. These range from the simple audio oscillator to the complex instrument generating an a-m r-f signal, with added provisions for sync and sweep output. A brief description of some specific models will indicate the nature of these types.

a. Simpson Crosshatch Pattern Generator, Model 485. This generator can be tuned for output on Channels 2, 3, 4, 5, or 6. The picture carrier for each of these channels is amplitude-modulated to produce horizontal lines, vertical lines, or a crosshatch of lines on the TV screen.

The output from the Model 485 is coupled to the antenna input of the receiver on any of the above channels. A nonactive channel is chosen. A feature of the Model 485 is a combination of vertical and horizontal sync pulses modulated on the picture carrier. This provides means for locking the pattern on the TV screen when the receiver vertical and horizontal hold controls are properly adjusted.

b. Hickok Television Video Generator, Model 650. The Model 650 incorporates a variety of features very useful in servicing a TV receiver, in addition to the crosshatch function. The selected output

of this generator may be one of the following:

(1) A dot- or bar-modulated picture carrier for each of the vhf channels.

(2) A video signal:

60 cps, vertical sync and sweep.
15,750 cps, horizontal sync and sweep.
900 cps, for horizontal bars (15).
315 kcps for vertical bars (20).

By means of a switching arrangement, selection of a variety of services is possible when the generator is set at either r-f or video output. Thus, the modulation of the r-f signal can be one of the following:

A dot pattern:
Crosshatch bar pattern;
Horizontal bars plus sync pulses;
Vertical bars plus sync pulses;
Sync pulses, 60 cps or 15,750 cps;
Unmodulated r-f; or
External modulation.

The video signal can also be selected for any of the above functions.

c. Supreme-Composite Video Generator, Model 665. This instrument provides a composite video signal in accordance with FCC video standards. This signal includes both horizontal and vertical blanking pulses, horizontal and vertical sync pulses, and exact equalizing pulses. In addition, a pulse video-modulating signal is generated, producing a dot pattern on the TV raster which is used for vertical and horizontal linearity and size adjustments. The inclusion of equalizing pulses helps assure proper interlace.

The Model 665 has no r-f output. However, the composite video signal may be used for modulating an external r-f oscillator.

The Model 665 may be used for troubleshooting the sync circuits, video amplifiers, and sweep circuits of a TV receiver. Adjustment of controls in these circuits is also facilitated.

3. Using a Crosshatch Pattern

a. Linearity Adjustments. Equal spacing of the horizontal bars in the crosshatch pattern indicates vertical linearity. Equal spacing of vertical bars indicates horizontal linearity. About 15 to 20 bars provide sufficient linearity information for the technician.

b. Size Adjustment. Vertical and horizontal linearity and size controls are set for a picture which completely fills the picture area, with proper aspect ratio (this is evidenced by crosshatch squares) and proper linearity.

G. Sweep Generator

This instrument, together with the marker generator and oscilloscope, comprises the alignment equipment needed by every modern service shop.

1. What It Is and Why It Is Used. The sweep generator is an f-m signal generator. When used in conjunction with the oscilloscope, it supplies the signal necessary for viewing the response curves of the tuned circuits in a TV receiver. It is used to tune the resonant circuits of the receiver for their proper response, according to the manufacturer's specifications. It is also used to troubleshoot these circuits by supplying the signal and tracing its progress.

2. Output Signal Characteristics

a. Frequency Range. The generator must produce the frequencies needed to cover the r-f and the picture and sound i-f's of the TV system. Most modern generators are designed to give this coverage on the vhf channels. Some manufacturers have also recommended vhf equipment for the uhf frequencies using harmonics.

b. Sweep Width (Deviation). Frequency deviation of the r-f signal about its mean frequency is accomplished in one or two ways, either electromechanically or electronically.

In the electromechanical method the capacitance across the tank circuit of the f-m oscillator is physically varied by a driving mechanism using the power line voltage as the sweep voltage. The rate of frequency deviation is the frequency of the power line voltage, usually 60 cps. The extent of frequency deviation is determined by the amplitude of the sweep voltage applied to the sweep mechanism. Most sweep generators have facility for varying the extent of deviation anywhere from 0 (just the r-f carrier) to 10 to 15 mc.

The electronic method differs from the electromechanical in that there are no moving parts. Again, either the capacitance or inductance of the oscillator tank circuit is varied by a sweep voltage (usually line voltage) affecting a reactance-type modulator circuit. The extent of deviation is again controlled by a sweep width control.

c. Marker Injection. Facilities for injecting either external or internal markers are usually available on sweep generators. Where internal markers are furnished, a switch throws in the marker, whose frequency may be set by a panel control. Where an external marker generator is used, the sweep generator may include a jack or connector on the panel for adding the marker; or it may be injected directly into the circuit under test. The marker shows, or marks, the frequency of various points on the response curve.

Both absorption and beat frequency (oscillating or pip) markers are used. In the latter type, spurious beats between the marker oscillator and other signal sources may give rise to false marker indications. These markers usually travel at a much faster rate across the screen than the regular marker as the marker generator frequency is varied. Some sweep generators incorporate provisions for the absorption-

type marker to locate the beat marker points on the curve. The technician must learn to identify and disregard spurious markers.

3. How It Works. Figure 2-6 is a simplified block diagram of a sweep generator employing two oscillators and a mixer tube.

The swept oscillator is tunable through a range of 170 mc to 220 mc. The extent of deviation is controlled by a sweep width control giving a variation from 0 to 19 mc.

The beat oscillator is also tunable, from 220 mc through 275 mc. On bands 2 and 3 the output from the beat oscillator and swept oscillator is fed to the mixer, where detection takes place.

The difference frequencies generated are used to cover the f-m and TV frequencies, not included in the tunable range of the swept oscillator.

The 60-cps power line voltage is used for sweeping the oscillator, and it is also used to supply sweep voltage to the oscilloscope. Using the same sweep voltage for the scope and sweep generator makes possible a stationary pattern on the scope.

An attenuator is available to adjust the level of r-f output.

A panel jack receives a signal from an external marker generator.

There are as many variations in the circuitry and operation of the sweep generator as there are manufacturers. However, the general principles outlined here apply basically to this type of instrument.

4. Controls. The usual controls found on a sweep generator are:

a. Tuning Control to choose the center frequency. Associated with this control may be calibrated dial showing center frequency markings for the various bands.

b. Band Selector to select the frequency bands shown on the tuning dial.

c. Sweep Width to vary the extent of frequency deviation. Associated with this control may be another, the sweep range control. This sets the range for which the sweep width is calibrated.

d. Output Control is a step or variable attenuator, or combination, to set the level of r-f output.

e. Phasing to control the phasing of the sweep voltage fed to the horizontal input of the oscilloscope. Adjustment of this control will cause the two traces which may appear on the oscilloscope to be superimposed.

5. Special Features. Sweep generators may also contain some of these special features:

a. Blanking. A blanking switch is included to kill the operation of the swept oscillator for 180 degrees of each modulating cycle. Thus, one of the traces is eliminated and a zero baseline appears on the oscilloscope for reference purposes.

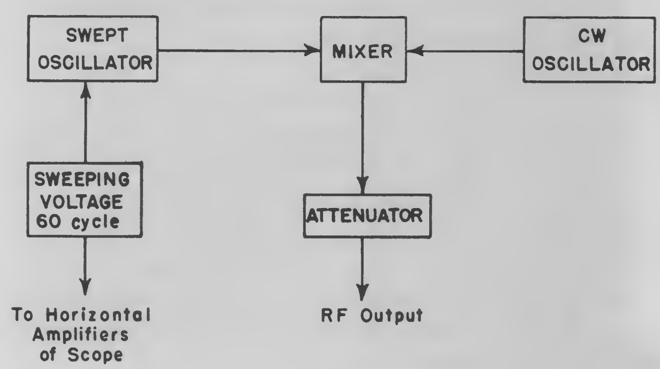


Fig. 2-6. Block diagram of sweep generator. Courtesy GE.

b. Crystal Markers. A special crystal oscillator, into which different frequency crystals may be plugged, for marking the response curve at critical points, such as 4.5 mc.

c. Variable Marker. This is an internal marker oscillator, variable over the required range of i-f and r-f frequencies, for marking the curve. This eliminates the need for an external marker generator. Facilities are usually included for checking the accuracy of the marker against crystals in the equipment.

d. Sweep Phase Reversal Switch. This is a switch for reversing the response curve on the oscilloscope for comparison with standard response curves shown in texts or manuals.

6. Interconnecting Sweep Generator, Marker Generator, Oscilloscope, and TV Receiver Section Under Test. The best procedure is to follow exactly the instructions of the equipment manufacturer and the TV receiver manufacturer as to proper generator termination, point of signal injection, point of viewing, proper bonding, signal level, etc. However, certain general principles may be stated which apply to all test set-ups.

a. Ground Connections. All test equipment and the receiver under test should be well grounded, preferably at the same point. It is desirable to mount the test equipment on a copper shelf, with provision for tying this shelf (by a short braided connector) to the TV chassis. The TV receiver should also be mounted on a copper ground plate. Both instrument shelf and receiver plane should be bonded at several points. The whole system should then be grounded. The common of the a-c power line is usually a good ground source. Otherwise, the water-pipe system may be used.

A good test of proper bonding and grounding is to add ground connections between the sweep generator and TV chassis. If these alter the response curve, then the grounding is inadequate. It is good practice to make the ground connection from the

sweep generator to the same point to which the circuit in the TV receiver is grounded.

b. Lead Length. The output connectors to the receiver and ground should be kept as short as possible. Generator cables should hang freely and should not be anchored to tubes, i-f cans, or other tuned circuits.

c. Bias Level. The agc controlled stages must be operated at the normal bias for a proper response curve. The use of a low-impedance bias box to set the bias on these stages is therefore essential for use with alignment equipment. The manufacturer's bias recommendations should be followed.

d. Signal Level. The r-f output level of the sweep generator should be kept as low as possible to prevent overdriving any stages, since an overdriven stage will distort the response curve.

e. Output Connectors. The manufacturer may provide properly terminated cables for balanced (300-ohm) and unbalanced connection to the receiver. If proper termination is not provided, the manufacturer's instructions should be followed for making up matching pads.

f. Typical Interconnection Hookups. Figure 2-7 shows a typical hookup of equipment using an external marker generator. Figure 2-8 shows a typical hookup of equipment, where the sweep generator has an internal marker.

g. D-C Isolating Capacitor. If there is ever any need to connect the sweep generator, marker generator, or any signal generator to a test point containing a d-c voltage, a blocking capacitor in series with the hot lead must be used. Otherwise, the instrument attenuator may burn out.

H. Marker Generator

1. What It Is and Why It Is Used. The marker generator is an unmodulated variable oscillator, covering the TV i-f and r-f range, which provides a signal for identifying the frequency distribution of a response curve. That is, it identifies the frequencies of the response curve and thus makes it possible to check its bandpass.

As we have already noted, this instrument can be a test oscillator contained in the sweep generator case, or it may be an external generator. Any a-m or unmodulated test oscillator may be used for marking. However, instruments specifically designated as marker generators or calibrators usually have added features not present in the test oscillator.

2. Frequency Calibration. One of these features is the inclusion of facilities for checking the frequency calibration of the marker generator. This is accomplished by incorporating a separate crystal-controlled oscillator in the instrument with plug-in receptacles for different crystal standards. The output of the marker generator is then mixed with the output of the crystal oscillator and detected. A zero beat (zero frequency difference, characterized by a null on either side of which an output exists) indicates frequency coincidence on the fundamental or harmonics, as the case might be.

The reason for this concern with the accuracy of the marker generator is that proper alignment of the receiver depends on accurate marker frequency. The technician should check the frequency of the generator whenever it is used for marking a response curve. Sufficient primary and secondary check points are provided by the manufacturer to insure accuracy over the entire range of usable frequencies. The manufacturer's procedure for calibration should be followed whenever possible.

Of course, any signal generator of known accuracy may be used as a secondary standard to beat with a marker generator for calibration of the latter. Thus,

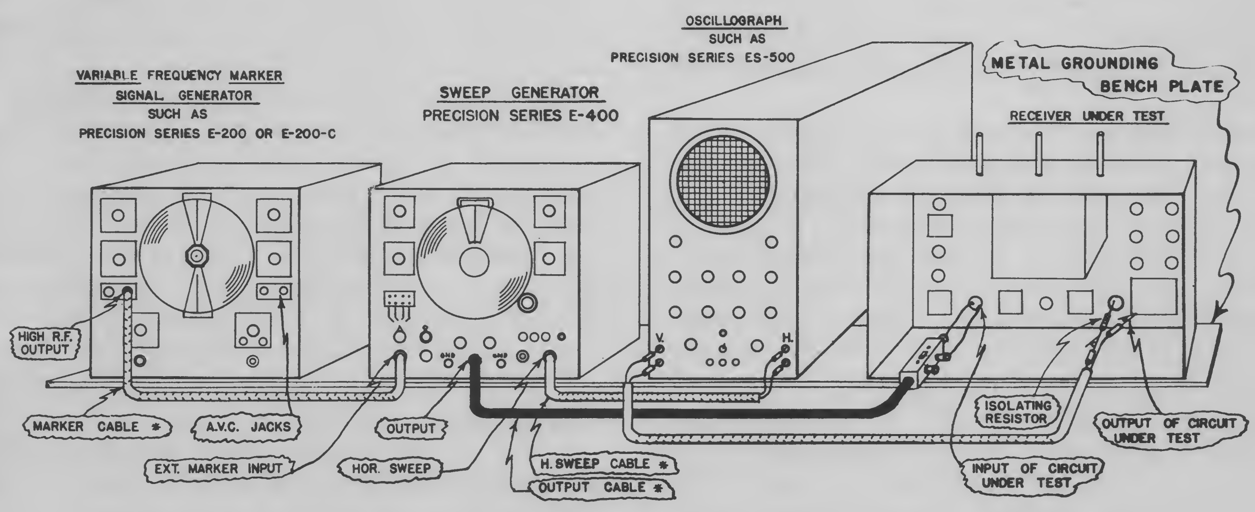


Fig. 2-7. Test equipment alignment set-up; separate marker and sweep generator. *Courtesy Precision Apparatus Co.*

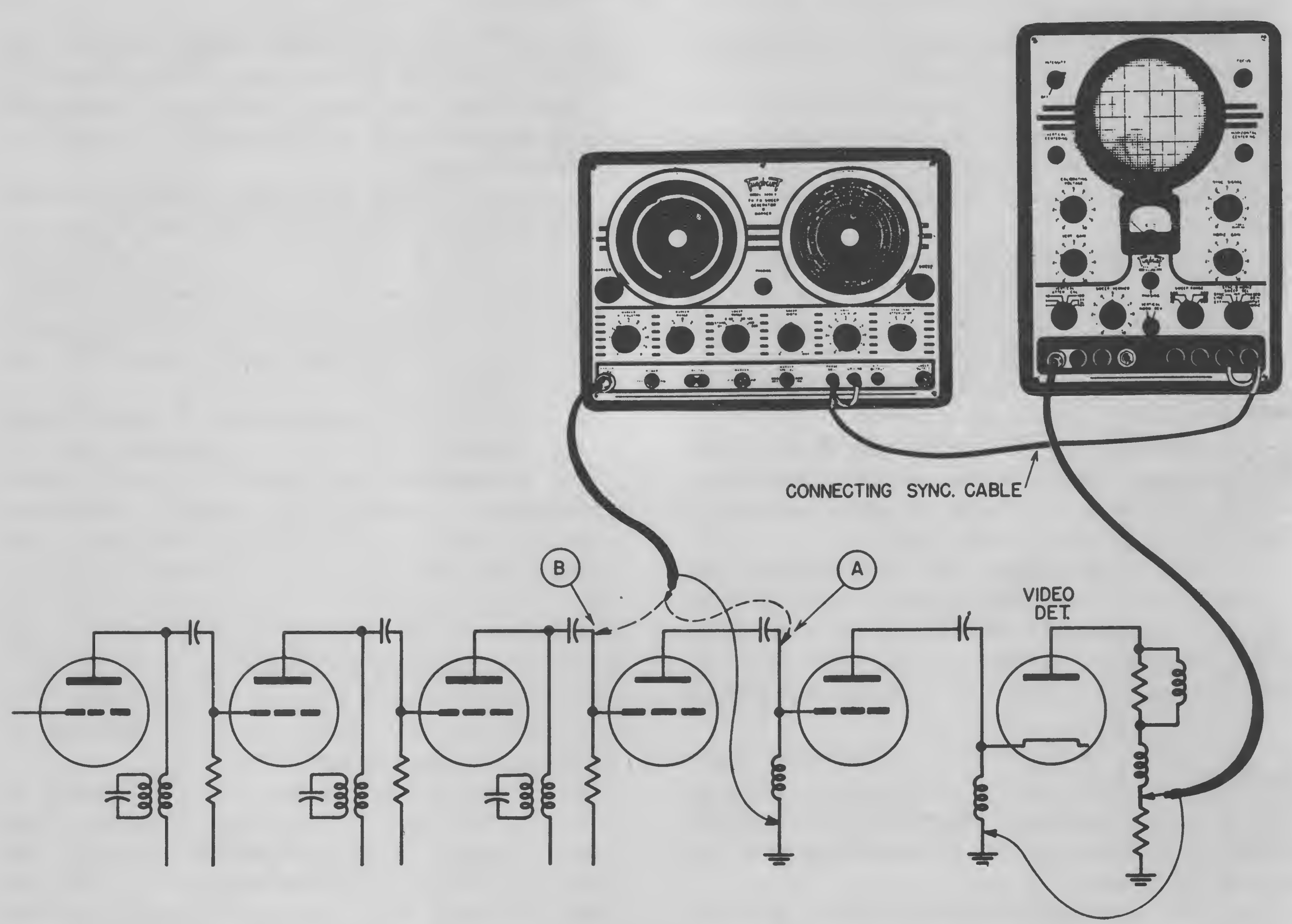


Fig. 2-8. Test equipment alignment set-up; combined marker and sweep generator. *Courtesy Triplett Electrical Instrument Co.*

it is possible to inject the output of the generator used as a standard and also the output of the marker generator under test into the i-f amplifiers of a TV receiver. An oscilloscope is placed across the load of the video detector. The marker frequency is varied for zero beat on the scope, and the frequncy setting is then compared with the setting on the standards generator. This procedure is possible in the i-f range of frequencies. The local oscillator of the TV receiver is removed in this process to avoid spurious beat notes.

Another method is to feed the two signals to the input of a scope demodulation probe and tune for zero beat. This can be used for checking any frequncy setting of the marker generator.

3. Marker Injection. In most cases the output of the marker generator can be patched into the sweep frequency generator, with the output of the latter instrument containing both signals. Where no such provision is contained in the equipment, the output of the marker generator must be loosely coupled to the circuit under test. Thus, the hot lead of the marker may be clipped to the insulation on the hot lead of the sweep generator, or an isolating resistor and capacitor may be placed in series with the hot lead of the marker generator before the signal is injected into the circuit under test. Point of injection may be in a stage before or following the circuit under test. The output of the marker generator is kept as low as possible. The purpose is to keep the marker generator from loading down the circuit, in order to prevent distortion of the response curve.

If the marker is broad or fuzzy, a 0.001 to a 0.01 mf capacitor, placed across the vertical input terminals of the oscilloscope, will sharpen it.

4. Controls. These usually include a function selector, band selector, output attenuator, and frequency selector (associated with calibrated dial). The functions of these and other controls are evident from the names of the controls.

5. Operating Procedure. There are individual variations in the operation of the equipment commercially available. As stated previously, the technician should follow the manufacturer's instructions and become thoroughly familiar with his equipment to get the most out of it.

Interconnection of the marker generator, sweep generator, oscilloscope, and receiver under test has already been illustrated.

6. Other Applications. If a marker generator has

an independent output terminal, it may be used just like any test oscillator. Some models also include facilities for amplitude-modulating the output signal. Some applications, other than determining the band-pass of a response curve, are:

a. Test Oscillator: To provide r-f signal for signal-tracing the r-f or i-f sections of a TV receiver in a signal substitution process.

b. Signal Source in Trap Alignment.

c. Signal Source in alignment process where sweep generator need not be used; for example, f-m i-f alignment.

I. A-M Test Oscillator

This is the familiar a-m signal generator used for radio and TV servicing. Its frequency range usually varies from about 100 kc to 40 mc on fundamentals. Harmonics are used in the higher frequency ranges.

As has already been mentioned, this test oscillator may be used as a marker generator, in addition to its other applications. When used as a marker generator, its frequency must be accurately calibrated. The technician may make a calibration chart for the important marker frequencies in the i-f and r-f bands.

When accurate calibration is difficult, the a-m generator may still be used as an additional marker. The marker generator is set at the proper frequency. Then the a-m generator is zero-beat against the marker and left at that point. Now the marker generator is available to mark a second point on the response curve.

J. Capacity Checker

1. What It Is and Why It Is Used. Capacity checkers available to the service technicians perform a variety of functions, depending on the design of the instrument. There is the tester which only measures the capacitance of a capacitor. Then there is the type which, in addition to measuring the quantity of capacitance (50 mmf, etc.) of a capacitor, also tests whether a capacitor is leaky, shorted, or open while operating at its rated d-c voltages. In addition, some types check the power factor of a capacitor and leakage current of electrolytic capacitors. Some also incorporate resistance measurements of resistors.

The functions that the checker performs determine the use to which the technician can put it. However, all types are useful in confirming the value of a capacitor as specified by its marking, in determining the capacitance of unmarked capacitors, and in matching pairs of capacitors.

2. Operation. The capacity tester usually includes an a-c bridge circuit and an indicator. The indicator may be a magic eye, a meter, or both. Terminal posts are available for connecting the capacitor under test. Function switches, polarity switches, etc. are marked on the instrument.

The operating instructions of the manufacturer should be followed in all cases.

3. Checking Capacitance of Small Capacitors

a. The residual capacitance of the instrument should be determined on its lowest capacitance range, with no capacitor across the terminals. This value is then subtracted from the value obtained in measuring the small capacitor.

If test leads are used, the residual capacitance of the instrument and leads must first be determined and correction made for this total value as before.

b. If a capacitor must be checked in the circuit, one end must be unsoldered and the measurement made with no power applied to the chassis.

4. Checking Capacitor in Circuit. Recently, a new capacitor tester was developed which makes it possible to check capacitors for open, shorted, or intermittent conditions without disconnecting the capacitor from the circuit. Of course, the circuit under test must be turned off before the tester can be used.

K. Field Strength Meter

1. What It Is and Why It Is Used. This instrument provides means for measurement of TV signals in any locality. It is usually designed for comparative, rather than absolute, measurements in antenna installations.

Some of the functions performed by this instrument are:

a. Location of maximum signal area.

b. Antenna orientation.

c. Adjustment of boosters.

d. Checking antenna and lead-in installations.

2. How It Works. The Simpson Model 488 is typical of the usual circuit arrangement of a field strength meter. It includes a 12-channel front end, two i-f amplifiers, a detector, and a meter. Provisions for 72- or 300-ohm input are available at the instrument. A phone jack for crystal phones is included to help the operator identify the signal being measured. A TV signal is identified by 60-cps sync buzz when the instrument is tuned to the picture carrier.

3. Operation. The antenna lead-in is attached to the input binding posts and the field strength meter is turned to "On." The channel selector switch is set to a channel which is on the air. The range switch is set to a higher range if the meter goes off-scale. Readings may then be taken from the meter.

For antenna location and orientation the antenna may be carried around the roof area while observing the signal strength indication. After the most effective location has been found, the antenna is mounted and oriented for maximum signal strength as shown on the meter.

4. Field Strength Measurements. Measurements may be made to determine relative performance of receivers in various locations. Comparative measure-

ments for different locations can be made and recorded. This data, together with consideration of receiver performance and type of antenna used, will help predict results that may be expected.

L. Audio Oscillator

1. What It Is and Why It Is Used. This is a sine-wave generator providing signal voltages throughout the frequency range of 20 to 20,000 cps; or higher, up to 200,000 cps. It can be used as a signal source for checking the performance of the audio and video amplifiers of a TV receiver. It can also be used to check the vertical and horizontal sweep linearity adjustments.

2. Checking Audio Circuits. The procedure is to inject the signal into the grid of the a-f amplifier and trace its progress through the audio circuits with an oscilloscope. This is particularly useful in finding causes for distortion in this part of the receiver. However, the input level must be low enough not to overdrive any stage. The progress of the signal is followed with the oscilloscope. The stage in whose input a normal signal appears, and in whose output a distorted sine wave appears, is the stage causing distortion.

The voltage gain of an audio amplifier may be computed from the fact that

$$\text{Gain} = \frac{\text{output voltage}}{\text{input voltage}}$$

where input and output voltages are the peak-to-peak voltages of the sine wave.

3. Checking Video Circuits. A similar procedure may be used in checking the video circuits and CRT. A signal is injected into the grid of the first video amplifier. If the video amplifiers are operating properly, the signal will appear as dark bars on the CRT screen. The number and orientation of bars will depend on the signal frequency. Thus, a 600-cps signal will cause 10 horizontal bars (multiple of 60) to appear, and a 1200-cps note will cause 20 horizontal bars. A signal whose frequency is a multiple of 15,750 cps will cause vertical bars to appear.

If bars do not appear on the screen, the progress of the signal through the video amplifier may be viewed with an oscilloscope and the defect localized.

4. Checking Sweep Linearity. The spacing between horizontal bars on the screen depends on vertical sweep linearity, and the spacing between vertical bars depends on horizontal linearity. Linearity is properly set when the spacing between bars is equal. In this manner, sweep linearity adjustments can be made using an audio oscillator.

5. Other Applications. This instrument may also be used for testing speakers, headphones, audio amplifier response, audio transformers, and filters.

M. Selenium Rectifier Tester

1. What It Is and Why It Is Used. The Jackson Electrical Instrument Company's Model 710 tests selenium rectifiers used in the power supplies of radio and television receivers. Rectifiers rated from 25v to 300v, with currents from 20 ma to 650 ma, may be tested under load.

The characteristics of a selenium rectifier which this instrument will test are:

a. Reduced rectification capabilities.
b. Shorted rectifiers.
c. High forward resistance.

2. Operation. This tester incorporates two features:

a. Jackson Sele-Rater.
b. Tester proper.

The Sele-Rater enables the technician to determine the ratings (voltage and load current) of a selenium rectifier, even though the manufacturer's ratings are unknown. With these ratings determined, the rectifier may then be tested.

For a complete operational procedure refer to the manufacturer's instruction manual.

N. Volt-Wattmeter

1. What It Is and Why It Is Used. This instrument measures the power drain (watts) of a receiver or any a-c appliance. It is useful in finding short circuits in receiver power supplies. It also measures a-c line voltage. Some manufacturers have included these additional functions: d-c voltmeter, a-c ammeter.

2. Servicing with the Wattmeter. An extra drain on the power supply of a receiver may be found as follows:

First, the power consumption of the receiver will show a marked increase. For example, a receiver rated at 225w, would read possibly 350w when it is loaded unduly. By removing the rectifier tube, or by opening up one end of the selenium rectifier, the technician can quickly see on which side of the rectifier the trouble exists. If the power transformer has shorted turns, the wattmeter reading would drop only slightly. If the short is on the rectifier side, the reading on the wattmeter will drop decidedly.

Now, let us presume that the wattmeter reading shows an appreciable drop, and that the rectifier has been checked and is known to be good. The rectifier tube is then replaced in the set. Presume the short to be a capacitor. The technician can unsolder one end of the suspected capacitors, one at a time, and watch the indications on the wattmeter. If the readings return to normal when this is done, the defective part has been found. Otherwise, the capacitor is resoldered and the process continued until the defective one is found.

The power drain of a TV receiver is usually stated on the back of the set or on the nameplate on the rear of the chassis.

O. Checking Test Instruments

The technician should perform periodic checks of his test instruments. This will eliminate uncertainty

as to the condition and operation of this equipment. It will also make it possible to prevent equipment breakdown and reduce maintenance time and costs.

Periodic (monthly, or more frequently if equipment is kept in constant use) inspection of equipment is recommended. In this check, the condition of test leads should be determined; also operation of controls, pilot lights, and mechanical features. Then sensitivity should be checked, and in the case of signal generators, the frequency calibration. Accuracy of meters on various ranges and the condition of probes should be tested.

Very few "standards" will actually be required. Crystals for checking the frequency calibration of signal and marker generators should be available; some resistors and capacitors for standards, several flashlight batteries, a line-monitoring voltmeter, a voltage calibrator, a variac, a d-c supply, and a crystal detector should also be available. These standards should be used only for instrument testing.

Checking of test equipment involves testing their performance characteristics and comparing these with either manufacturer's ratings or with data secured by the technician himself. It is recommended that, on the purchase of a piece of test equipment, the technician perform the checks suggested below and keep a written record of performance. The results of periodic checks should also be logged and compared with initial ratings. Where changes appear, the cause for these should be investigated. It is important to keep test conditions the same at all times. Thus, line voltage should be maintained the same. The use of a variac or similar device is recommended in this connection.

1. Oscilloscope. The vertical sensitivity of an oscilloscope can be checked very simply. A 6.3-v a-c signal output (this can be from the voltage calibrator or an ordinary filament transformer) is applied across a voltage divider (Fig. 2-9) made up of two 5 percent resistors, R1 and R2, 100 K and 500 ohms, respectively. The voltage across R2 is then fed directly to the vertical input of the scope, which is set for maximum vertical gain. The vertical deflection of the trace is measured in inches with a ruler. The vertical deflection sensitivity (peak-to-peak) may then be calculated by dividing 90 by the measured number of inches. The rating is in millivolts/inch. The reason 90 is used is that the divider ratio 500/100,500, or approximately 1/200 times 18v, equals 90 mv. This is the voltage applied to the vertical input of the scope.

Example: If the beam was deflected vertically 3 in., the peak-to-peak sensitivity is

$$\frac{90}{3} = 30 \text{ mv/in.}$$

The rms deflection sensitivity may be obtained by dividing 31.5 by the measured number of inches.

Similarly, by applying the same signal to the horizontal amplifier set for full gain, and measuring the horizontal deflection, horizontal sensitivity may be computed.

2. VTVM, VOM. The resistance ranges may be checked by measuring a group of selected resistors kept as standards. Also, it should be possible to set the zero-ohms control properly without any trouble. If this cannot be done, then the meter probably needs new batteries.

The low-voltage d-c range can be checked with several small flashlight cells or with 4½-v batteries. The higher voltage ranges can be checked by measuring the output of the d-c supply standard, which the technician can build very easily or can purchase commercially. Another possible standard is the use of a TV receiver known to be in good operating order. The technician can check several power supply voltages in the TV receiver with a VTVM or VOM known to be in good operating order. He can then compare these with the readings obtained with the instrument being checked. Of course, with either method the line voltage should be monitored with the line meter and adjusted with the variac for its properly rated value.

The output of the voltage calibrator can be used as an a-c source for checking the a-c ranges.

3. Sweep and Marker Generator and A-M Generator

a. Frequency Calibration. Every manufacturer of signal generators has some provision for frequency calibration of these instruments. The technician should have available the crystals recommended by the manufacturer and required for calibration. The general method of calibration has been explained.

The center frequency of sweep generators may be determined by placing the detected response of the sweep and calibrated marker generator on an oscilloscope. The marker pip is manipulated to remain on the screen, while the generator sweep width is gradually reduced to zero. The center frequency of the generator is then read from the marker dial, at zero sweep.

The sweep deviation may be checked by running the marker pip from one end of the sweep generator response curve to the other and computing the difference between the marker's two frequency settings.

b. Output. In addition to frequency stability, the output of the signal generator should be checked periodically. This can be done with a crystal detector

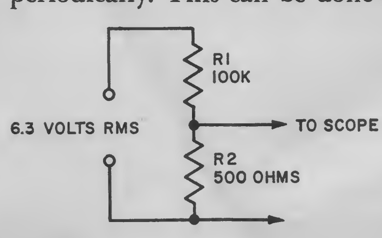


Fig. 2-9. Checking oscilloscope deflection sensitivity.

and microammeter. Figure 2-10 shows the hookup of a balanced crystal detector and meter. The most sensitive current range of the VOM can be used for this application. The generator should be checked at maximum output on every band, at the low and high ends and the middle of the band.

c. Sweep Generator Output Linearity. This characteristic may be checked by applying the output of the sweep generator to the oscilloscope through the demodulation probe of the oscilloscope. The gain of the oscilloscope and the output of the generator are set at maximum, with full deviation of the sweep generator. If the generator has a blanking feature, this is turned on. The detected output will appear as a straight line on the oscilloscope if there is no variation in amplitude of output of the generator as it is being swept through its range of frequencies, and if the response of the demodulation probe is flat over the range of sweep oscillator frequencies. Nonlinearity in output will appear as a nonlinear trace on the oscilloscope.

If the sweep generator response is nonlinear, the general characteristics of the response should be logged and compensated for in using the generator in alignment.

Linearity of the sweep generator should be checked over the i-f range and on each of the TV channels.

4. CROSSHATCH GENERATOR. The r-f function can be checked just like the signal generator, both as to frequency and output level. In addition, the signal can be fed to the antenna terminals of a TV receiver, known to be in good operating condition, in order to check the crosshatch pattern.

The video signal 60-cps and 15,750-cps sweep pulses can be checked with an oscilloscope as to amplitude and frequency. The oscilloscope sweep speed can be calibrated for 60 cps and 15,750 cps by the sweep circuits in the TV receiver.

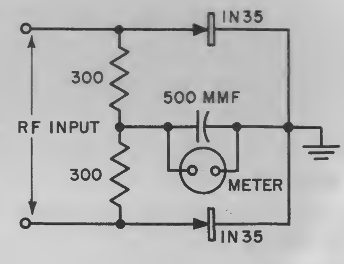


Fig. 2-10. Testing generator output.

5. AUDIO OSCILLATOR. The output level of this instrument can be checked by feeding the signal to the vertical terminals of a scope, after terminating the output properly. The gain of the oscillator is maintained at maximum or some other predetermined level. The oscilloscope gain controls are then calibrated at a convenient level, and the calibration and results logged.

The lower frequencies of the audio oscillator can be checked on 60 cps and harmonics of 60 cps. The scope sweep is set at 60 cps by using the 60-cps line frequency as a standard. If the dial of the audio oscillator is properly calibrated at 120 cps, two cycles will appear on the scope trace; at 300 cps, five cycles will appear on the trace, etc.

6. CAPACITY CHECKER. The capacity checker can be tested by the use of a group of capacitors set aside as standards and covering all the ranges of the instrument.

7. FIELD STRENGTH METER. This instrument can be tested for its frequency and sensitivity by a marker generator whose characteristics have been verified.

CHAPTER 3. SWEEP SECTION SERVICING

I. GENERAL INFORMATION

1. Function of Sweep Circuits. *The sweep circuits of a TV receiver generate the vertical and horizontal sweep currents or the voltages which deflect the beam properly so that it traces out the raster on the CRT.* The student is referred to any standard text on the method of interlaced scanning used in our TV system.

It is the sweep circuits in the TV receiver which control the position of the scanning beam so that, when properly synchronized with the transmitter sweep circuits, a picture is traced out on the CRT.

2. Linear Deflection. At the camera tube, the scanning beam moves equal distances in equal intervals of time; that is, its position is changing linearly with respect to time. This is what we mean by linear deflection, or a linear sweep.

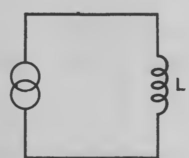


Figure 3-1

Figure 3-2

At the receiver the scanning beam must also move linearly with relation to time. If it did not, nonlinear distortion would result. This is the familiar crowding together of the picture, either horizontally or vertically.

Most present-day commercial TV receivers use electromagnetic deflection. In this system, the current flowing through a deflection coil sets up a magnetic field about the neck of the CRT, which interacts with the magnetic field associated with the electron beam. For a linearly changing magnetic field, a linearly changing current is required.

For an ideal inductance (Fig. 3-1) — that is, a coil having only inductance and no resistance — a rectangular voltage *E* (Fig. 3-2) applied across it will cause current *i* (Fig. 3-3) to flow linearly through the coil.

Figure 3-3

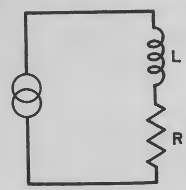


Figure 3-4

Figure 3-5

Since every coil contains both inductance and resistance (Fig. 3-4), the shape of the ideal voltage required to cause current to flow linearly through the coil must be modified. The extent of modification depends on the relationship between resistance and inductance of the coil. Such a modified waveform would be the familiar trapezoid in Fig. 3-5.

In actual practice the idealized voltage waveform of Fig. 3-5 is rarely obtained. What is normal for a particular circuit will depend on the circuit constants. Usually, the service manual for a TV receiver shows typical waveforms which a technician may expect at specific points in the circuit. Here too, however, the technician must be wary, for the waveform may be just an idealized drawing and not the actual photograph.

II. COMPARISONS OF VERTICAL DEFLECTION CIRCUITS

(Latest Receiver Models)

A. Vertical Oscillator

This circuit generates the modified sawtooth waveform required for vertical deflection. TV sweep oscillators are basically free-running oscillators; that is, they do not depend on an external triggering pulse for their operation. However, an external synchronizing pulse is applied to the input of these oscillators to lock them in at the proper vertical frequency, 60 cps.

Current model TV receivers use one of the following types of vertical oscillator circuits:

- Blocking oscillator.
- Cathode-coupled multivibrator.
- Plate-coupled multivibrator.

A comparison of these circuits will show that they produce the same output in a slightly different manner. The main point of difference is in the way in which feedback is accomplished.

1. Blocking Oscillator. The Crosley Chassis 402 uses a blocking oscillator in the vertical sweep circuits (see Fig. 3-6). This is typical of the blocking oscillators found in these recent receivers: CBS-Columbia, Chassis 1027; Motorola, Chassis TS-292A-00; Wells-Gardner, Chassis GS-40; DuMont RA-162; Hallicrafter AG-1200D; Stromberg-Carlson, Chassis 521; Raytheon 17T1; Admiral, F and K Chassis. Figure 3-6 shows that V104A (one half of a 12BH7) is the oscillator, while the second half of this tube

(V104B) is the vertical output amplifier. The oscillator is free-running. A positive-going vertical input sync pulse derived from the sync output stage is coupled to the control grid, pin No. 7 of V104A. This locks the oscillator at 60 cps, the vertical sync frequency.

It should be noted that the sync pulse controls only the frequency of V104A. It is required for that reason alone, and the oscillator circuit would operate without it; however, the oscillator would lose synchronization in its absence, and the picture would not hold vertically. V104A operates alternately at saturation and cut-off. Transformer, T103, supplies feedback in proper phase between the plate and grid circuit to sustain oscillation. If the primary or secondary of this transformer were to open or short, the circuit would cease to oscillate.

The main frequency determinants consist of C135 and R146 (the vertical hold control). It is this combination which maintains V104A below cut-off, after the brief interval of conduction. The "On" interval (retrace) is about 7 percent and the "Off" interval (trace) about 93 percent of the total cycle. If C135 or R146 change in value, the frequency of oscillation is affected. Thus, an increase in either capacitance and/or resistance will decrease the frequency, and vice versa.

The network which shapes the voltage at the output (plate) of the oscillator consists of C138 and C137 in parallel with R150. The resistor is known as the *peaker,* while C138 is the charge-discharge capacitor. This combination produces the trapezoidal waveform required for linear deflection. See waveform in control grid (pin No. 2 of vertical amplifier, Fig. 3-6).

If C138 decreases in value, the output at the plate of V104 will increase, and picture height will increase, and vice versa. However, linearity is affected.

Also, the amplitude of signal output (and hence, the height of the picture) is determined by setting of the height control, R147. *Decrease* in height follows *increase* in value of R147 in the circuit.

A leaky C138 will also result in decreased height. It should be noted that the plate is returned to boost B+. A reduction in this voltage will reduce the picture height. A variation from this typical circuit involves returning the V104A grid toward B+, rather than to ground. This increases circuit stability. In another variation the blocking oscillator transformer is placed between grid and cathode. The cathode winding takes the place of the plate winding found in Fig. 3-6. In other respects the circuit is identical with that of Fig. 3-6.

The turns ratio of T103 is critical. Any change in this ratio will affect the frequency, shape, and amplitude of the voltage output, and hence, the synchronization, size, and linearity of the picture.

The V104A grid waveform (Fig. 3-6) is typical of the waveform to expect in other blocking oscillator grid circuits. The PP amplitude is about 90v.

The output waveform at the plate is also typical. Its amplitude is about 100v PP.

Identifying Characteristics. To summarize, a blocking oscillator is characterized by use of the following:

a. A single tube — a triode.

b. A transformer between plate and grid, or grid and cathode, to sustain oscillation.

c. A variable resistor (hold control) and a fixed capacitor, forming the frequency-determining time constant, in the grid of the tube.

d. A variable resistor (height control) in the plate circuit to control amplitude of output, and hence picture size.

e. A positive sync pulse applied to the grid to control frequency.

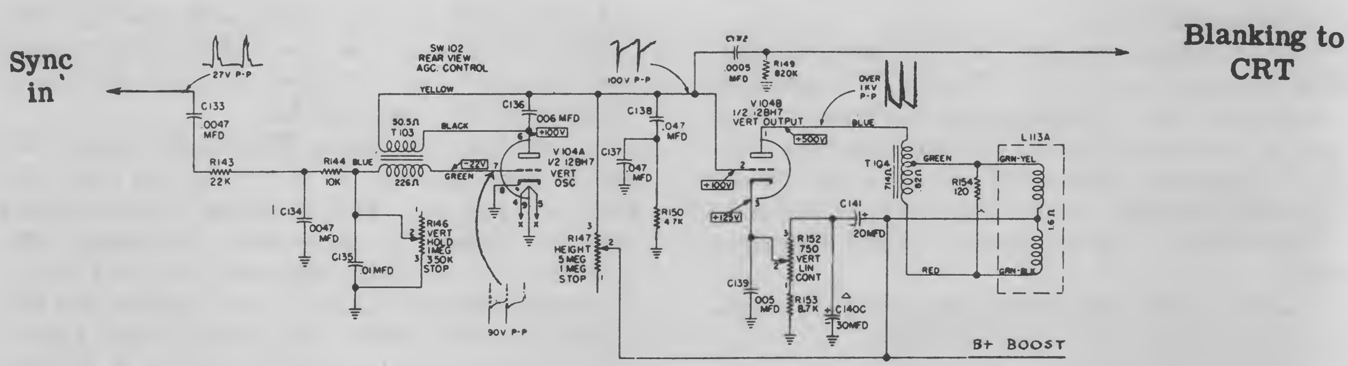


Fig. 3-6. Vertical sweep: Crosley chassis 402.

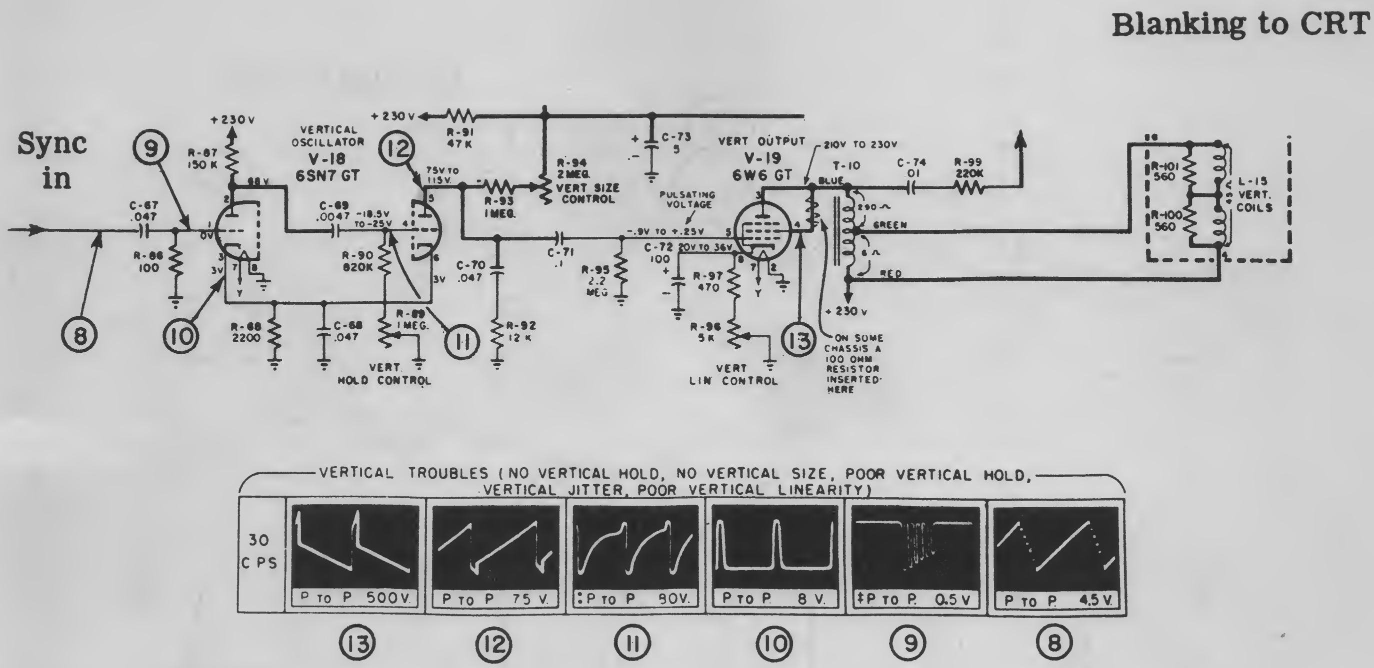


Fig. 3-7. Vertical sweep: Emerson Model 727D.

2. Cathode-Coupled Multivibrator (Fig. 3-7). In Emerson Model 727D, a cathode-coupled multivibrator is used as the vertical oscillator. The function is the same as that of the blocking oscillator; that is, to generate the modified sawtooth voltage required for vertical deflection. Again, this circuit is typical of cathode-coupled multivibrators found in recent models, such as the Hoffman Chassis 195.

The two triodes in V18, a 6SN7, are used as the free-running oscillator. Operation is characterized by the fact that the tubes conduct alternately. The left-hand triode is the normally "On" tube, while the right is the normally "Off" tube. Feedback to sustain oscillation is accomplished by the common cathode resistor, R88, whose value is chosen for best feedback conditions. The usual size of this resistor in the vertical circuits varies between 1 K and 5 K. If this resistor opens or changes appreciably in value, oscillation will stop.

The main frequency determinants are C69 and the two series resistors, R89 and R90. R89 is the vertical hold control. Increase in the values of either or both of these components will decrease oscillator frequency, and vice versa.

A negative-going sync pulse is applied to the input to this circuit (grid, pin No. 1). The output from this oscillator is taken from plate, pin No. 5. Here is contained the shaping network consisting of C70 and R92 (the peaking resistor). The usual value of C70, the charge-discharge capacitor, for vertical circuits is about 0.05 mf.

The usual variation of R92 is from 3 K to 15 K. Increase or decrease in capacity of C70 will cause respective decrease or increase in picture height. This shaping network is similar to that previously discussed in the blocking oscillator output circuit.

Height of the picture is controlled by R94, the vertical height control in the plate, pin No. 5. Its operation and effect are identical with that in the circuit of Fig. 3-6.

Typical waveforms in this circuit, checked with an oscilloscope and low-capacitance probe, are shown in Fig. 3-7. The check points are at the common cathode (pin No. 3 or No. 6), the control grid (pin No. 4), and the output plate (pin No. 5).

A good check to determine whether the circuit is oscillating is to check voltage at the output grid (V18, pin No. 4). If a VTVM is used, the voltage here will be approximately 20v negative. In other receivers using this type of oscillator, the usual range of voltages in this grid will be 15 to 35v negative. A 20,000 ohms/volt meter will give lower voltage readings here.

Identifying Characteristics. A cathode-coupled multivibrator is characterized by use of:

a. Two triodes, with *RC* coupling from the plate of the input tube (normally, "On") to the grid of the second tube (normally, "Off").

b. A common cathode resistor, with or without a parallel capacitor, as the feedback path to sustain oscillation.

c. An *R* (hold control) *C* (coupling) network in the grid of the normally "Off" tube, to determine frequency.

d. A variable resistor (height control) in the plate of the normally "Off" tube, to control picture height.

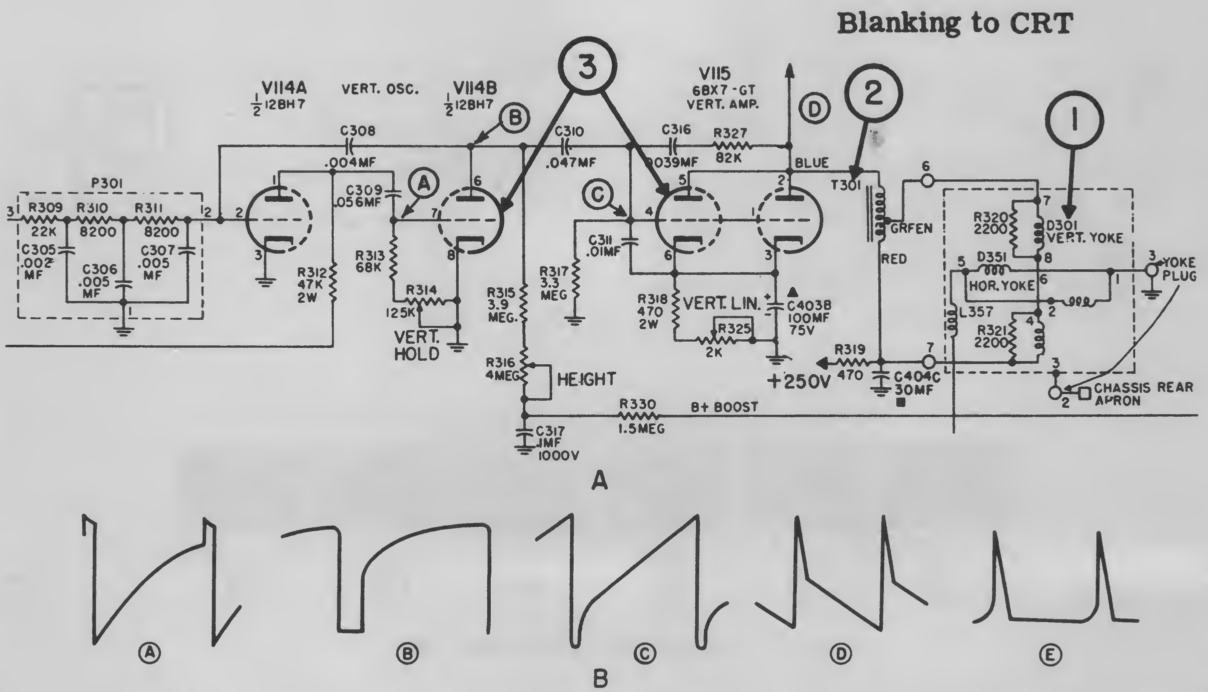


Fig. 3-8. Vertical sweep: GE Model 137C125.

e. A negative sync pulse applied to the input grid, to synchronize the circuit.

3. Plate-Coupled Multivibrator. Typical of this oscillator is the circuit used in the GE Stratopower Chassis, Model 17C125 (Fig. 3-8). The oscillator consists of the two triodes in the 12BH7: V114A, and V114B.

Operation of this circuit is similar to that of the cathode-coupled multivibrator, except that feedback occurs from the plate of V114A to the grid of V114B through C309, and from the plate of V114B back to the grid of V114A through C308. If either of these capacitors opens, the circuit will not oscillate. V114A is the normally "On" tube, while V114B is the normally "Off" tube.

The main frequency determinants are C309 and R313 in series with R314 (vertical hold control). An increase in value of these components will result in a frequency decrease, and vice versa.

The waveshaping network consists of the feedback network C316 and R327. Thus, the rectangular pulse at the plate of V114 is peaked and the resultant input waveform appears in the grid, pin No. 4 of the amplifier, V115. (See Fig. 3-8.)

The input to this free-running oscillator is a negative-going sync pulse at grid, pin No. 2 of V114A. The output is taken from the plate on V114B, pin No. 6.

A variation of this circuit is contained in the vertical oscillators used in the following receivers: RCA, 17T301; Capehart, CX-37; Zenith, 19L25; DuMont, RA-160.

The schematic diagram in Fig. 3-9 shows the Capehart circuit. The main difference between this and the circuit just described is the fact that the output tube, V502, is part of the oscillator, the second tube being V501. Voltage changes in the plate of V501 are coupled by C352 to the grid of V502. Voltage changes at the plate of V502 are coupled to the grid of V501 by the network consisting of C529, C530, and R534. The trapezoidal waveform required for sweep deflection is generated by C533 and R535 and the parallel combination of R537, R538, and C534. In this circuit, V501 is the normally "Off" tube and V502 is the normally "On" tube. Here, the sync is applied to the grid of V501, the normally "Off" tube. Thus, a positive-going sync pulse is required.

Identifying Characteristics. A plate-coupled multivibrator is characterized by the use of:

a. Two tubes, with *RC* coupling from the plate of the first to the grid of the second and back from the plate of the second to the grid of the first.

b. This coupling network is the feedback network.

c. Main frequency determinants are the same as in the cathode-coupled multivibrator; that is, the *RC* network is the grid of the normally "Off" tube.

d. A variable resistor in this grid circuit is the hold control, while a variable resistor in the plate circuit of the normally "Off" tube is the height control.

e. Synchronization is accomplished by a negative-going pulse applied to the input grid of the normally "On" tube, or a positive-going pulse to the input of the normally "Off" tube.

B. Vertical Amplifier (Output)

The original basic circuit used as a vertical amplifier has undergone little change in current TV receivers.

1. Operation. Figure 3-7 shows V19, a conventional power amplifier. The trapezoidal or sawtooth waveform is coupled by C71 from the output of the vertical oscillator to the grid of V19. The amplified signal (current amplification) is transformer coupled to the vertical deflection yoke. T10 can be a conventional transformer, or it can be an autotransformer as it is here. Autotransformers are more frequently used now because of their greater efficiency.

Refer again to Fig. 3-7. Variable resistor, R96, in the cathode of V19 is the vertical linearity control. By changing the bias, and hence the operating point of the tube, the tube characteristic is utilized in improving the linearity of the applied waveform. The cathode of V19 is bypassed in typical fashion by a large (100-mf) electrolytic capacitor to maintain a fixed bias on this tube. The cathode is at 30v, thus setting the operating point for Class A amplification.

The circuit of Fig. 3-7 illustrates a recent trend in receiver design. This is the use of vertical retrace blanking. The sweep voltage is applied from the vertical output transformer to the grid or cathode of the CRT in such a polarity as to blank-out the CRT during retrace time. In the illustration shown, a positive-going pulse is applied for this purpose to the cathode of the CRT from plate, pin No. 3 of V19.

Defects in this circuit will affect the height of the picture. Thus, if the coupling capacitor C71 is open, there will be a bright, narrow horizontal line on the screen (no raster). If C71 is leaky, vertical foldover will occur. A shorted C72 will also cause foldover and increased height. An open C72 will reduce picture height. An open output transformer will cause loss of vertical sweep.

Shorted turns in the output transformer will give rise to a variety of effects. Mainly, though, there will be reduced picture height. If resistors R100 or R101 in the deflection yoke open, ringing may occur. These are damping resistors whose function is to eliminate oscillation in the vertical windings of the deflection yoke.

2. Manufacturer Differences. Comparison between Fig. 3-6 (Crosley) and Fig. 3-7 (Emerson) shows that the vertical output amplifier, V104B, in Crosley is essentially the same as that in the Emerson just described. A difference is in the method of coupling from the oscillator to the amplifier. In the Emerson, *RC* coupling is used (R95 and C71), whereas the Crosley is direct-coupled. In the Crosley, this brings the grid of V104B at 100v. Proper bias is maintained by a large cathode resistor, making the cathode of V104B 125v positive. Of course, different tubes are used. Emerson employs a 6W6; Crosley, one half of a 12BH7.

Moreover, retrace blanking in the Crosley is accomplished by feeding the waveform from the grid of the amplifier to the control grid of the CRT, as opposed to the method previously described for the Emerson.

Another difference is in the amplifier plate return B+. The Crosley is return to boost B+, 520v; the Emerson to +230v.

Comparison of the Emerson with the Capehart amplifier, V502 in Fig. 3-9, again shows the similarity in circuitry. A difference is in the use of a conventional output transformer used in the Capehart, as opposed to the autotransformer used in the first two circuits described.

3. Identifying Characteristics. Current-model vertical amplifier circuits show the following characteristics:

a. A power tube is used as a Class A amplifier. Tube is usually a triode, or triode-connected power pentode.

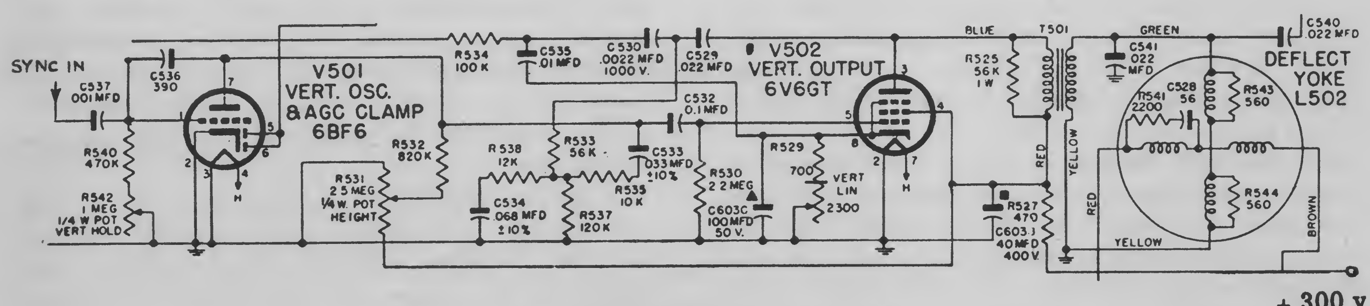


Fig. 3-9. Vertical sweep: Capehart CX-37.

b. The amplifier is coupled to the vertical deflection yoke by an impedance-matching autotransformer or a conventional transformer.

c. The cathode usually contains a linearity control.

C. Vertical Controls

The three controls normally associated with the vertical sweep section are: vertical hold, height, and vertical linearity. The proper adjustment of these controls can be facilitated by the use of a test pattern or a crosshatch generator.

1. VERTICAL HOLD. This control should be set to the middle of the lock-in range. Improper setting of the hold control may cause vertical instability or drift, or improper interlace. Poor interlace will show up in the horizontal wedges of a test pattern, which will have a lacy appearance. Loss of interlace causes pairing of lines.

2. VERTICAL SIZE AND LINEARITY. These controls are complementary. Adjustment of one may require readjustment of the other until proper balance has been reached.

The vertical size control should be adjusted until the picture fills the mask vertically; the linearity control, for the best over-all vertical linearity. Proper adjustment will be indicated by equal vertical wedges on the test pattern, or by equally spaced horizontal lines when using a crosshatch generator.

The linearity control will have the greatest effect on the top half of the picture.

It is good practice to set these controls so that the picture is slightly larger than the mask, consistent with good linearity.

3. OTHER VERTICAL CONTROLS. Some receivers employ additional controls to assist in adjusting the vertical circuits.

a. Vertical Peaking (Fig. 3-10). This control, a 10 K potentiometer, is used in RCA Chassis KCS 68F. In this circuit the grid of the output tube is

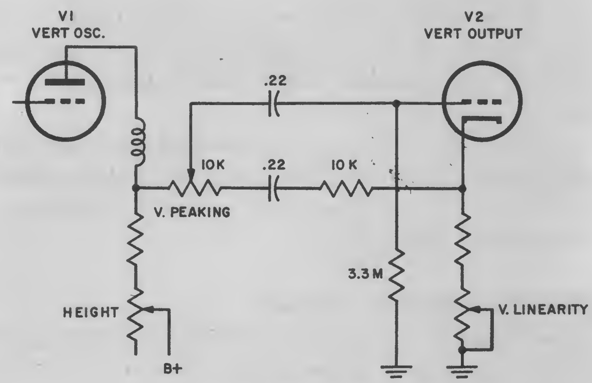


Fig. 3-10. Vertical peaking control.

coupled to the arm of the potentiometer. This, in turn, is in the high side of the charge-discharge circuit. This control is used in conjunction with the vertical linearity and size controls to adjust for best linearity.

b. Vertical Hold Range Control. This control permits vertical hold to be maintained over a wider range of component variations, while still maintaining a greater lock-in range on the hold control. This coarse adjustment should be made to set the hold control in the middle of its range. As used in the Zenith 19L26 chassis, it is simply a rheostat in series with the regular hold control.

c. Vertical Positioning Control. This control facilitates positioning of the raster on the screen. A bypassed potentiometer is used with the vertical deflection coils and a potential difference is placed across the potentiometer. By varying the potential difference across the windings, the beam is moved either up or down. This control is adjusted to give the best vertical centering of the raster on the CRT screen.

Mechanical positioning controls are used extensively in recent receivers.

III. TROUBLESHOOTING THE VERTICAL SWEEP CIRCUITS

A. Visual Indications of Sweep Circuit Defects

As has been previously stated, the first step in troubleshooting a defective TV receiver is to analyze the information contained in the picture, sound, and raster, and to localize the defect to a specific section. Visual analysis of the picture and raster give the most direct clues to defects in the sweep section. Sound gives an indirect clue.

For example, consider a receiver with absence of normal raster. Sound is normal, however, and there is a bright horizontal line on the screen. The fact that sound is normal would lead us to conclude that the sound section and the power supply used by the sound section are operating properly. Moreover, the existence of a bright horizontal line on the screen indicates that the horizontal sweep circuits and high-voltage circuits are operating normally. Hence, we can conclude that the power supply common to the vertical and horizontal sweep section is operating properly. This would lead us to suspect the vertical sweep section, which includes the vertical oscillator, vertical amplifier, the associated circuitry, and the vertical deflection coils.

In general, the following symptoms point to possible troubles in the sweep section, including deflection yoke and either vertical or horizontal stages, and depending on whether the defect affects vertical or horizontal deflection.

a. Raster or picture with insufficient height or width; weak or total absence of raster.

b. Raster or picture with vertical or horizontal foldover.

c. Raster or picture with vertical bars (ringing).

d. Keystoning.

e. Nonlinearity, either vertically or horizontally.

f. Loss of synchronization. This may also be due to defects in the sync section, video section, etc.

B. Instruments Required to Service Sweep Section

The instruments required to service the sweep section properly are:

1. Cathode-ray oscilloscope with low-capacitance probe and direct probe.
2. Oscilloscope voltage calibrator.
3. VTVM or VOM 20,000 ohms/volt meter.
4. Tube tester, and a stock of known good replacement tubes.
5. Capacity checker.

C. Troubleshooting Techniques

1. GENERAL. The basic troubleshooting procedure outlined in Chapter 1 applies to the vertical sweep circuits, as it does to other sections of the receiver. Briefly restated, it is as follows:

a. Isolate Defective Section by screen and sound indications.

b. Visual Inspection of Defective Section for obvious defects.

c. Adjust Controls in Defective Section that may affect its operation. In vertical sweep this includes hold, height, and linearity.

d. Replace tubes in defective section with known good tubes.

e. Use Test Equipment if above steps do not clear up the defect.

2. ISOLATING DEFECTIVE STAGE WITH OSCILLOSCOPE. The oscilloscope is the best tool the technician has to check for trouble in these stages. Signal-tracing with the scope is dynamic testing. We know that the vertical oscillator is a free-running oscillator which generates, in most cases, either a sawtooth or a modified sawtooth wave. This wave is then coupled to the amplifier. After amplification, the signal goes to the vertical deflection coil through an output transformer.

At check points in this series, a signal voltage of definite amplitude and shape must be present during normal operation. The process of troubleshooting these stages takes this into account. The technician simply follows the progress of the signal from start to finish. If a normal signal is present in stage A, but not in the succeeding stage B, then either stage B is defective or the coupling circuit between A and B is defective.

There are many variations in waveforms and amplitude. Hence, the manufacturer provides the technician with a guide to follow. Most service manuals incorporate waveform and amplitude information at critical check points.

In the signal-tracing process it is possible to start at the beginning (output of vertical oscillator) and work toward the deflection coils. Or one may start at the deflection coils and work back toward the oscillator. It is also possible to start at the midpoint, say, the grid of the vertical amplifier. If a proper indication appears there, then we can assume that the oscillator and its coupling circuits are working properly, and we trace the signal toward the deflection coils. If the proper waveform does not appear at the midpoint, then we trace back toward the input of the vertical oscillator. If the oscillator appears to be operating normally, we check for possible loading effect by the stage following the midpoint.

3. WAVEFORMS IN VERTICAL SWEEP SECTION

a. Cathode-Coupled Multivibrator. Refer to Fig. 3-7 for the circuit diagram of the vertical sweep section, which contains a cathode-coupled multivibrator. Critical test points are shown in Fig. 3-7, together with the waveforms and amplitude of signal to be found there. A low-capacitance probe is used with the scope. The scope sweep speed is set at 30 cps. These numbered test points in the diagram are:

10. Cathode, pin Nos. 3 to 6 of V18.

11. Grid, pin No. 4 of the normally "Off" tube of the oscillator.

12. Output plate, pin No. 5 of the oscillator. The same waveform will be found at the control grid, pin No. 5 of the 6W6.

13. Plate, pin No. 3 of the 6W6. This same waveform, somewhat lower in amplitude, will appear across the vertical coils of the deflection yoke (L15).

If the trouble is vertical (jitter or inability to obtain vertical hold), the trouble may be in the sync circuits. This may be checked quickly by varying the vertical hold control. If this momentarily stops (that is, holds) the picture, the trouble is not with the oscillator but in inability to synchronize the oscillator. The technician will then check to see if the vertical sync pulse appears at the input grid, pin No. 1 of the oscillator (test point 9). If the pulse is not there, or is disturbed or has insufficient amplitude, then the trouble lies in the sync circuit. This will be discussed under "Sync Section Servicing."

One other point should be noted. If there is the proper waveform in the output plate of the oscillator (pin No. 5 of V18), but no waveform appears in the grid (pin No. 5 of V19), then the coupling capacitor C71 is open.

Conclusion. In conclusion, we may say that the os-

cilloscope was used to follow the progress of the signal to the point where it disappeared, became distorted, or suffered abnormal loss in amplitude. The trouble then lies between the last check point where the signal was normal and the next check point where it was found abnormal or missing. We have thus isolated our trouble to the defective stage or component and can now use the VTVM to measure voltage and/or resistance in this stage.

If the oscillator fails to oscillate, none of the waveforms taken at test points (10) through (13) will be seen. Reasons for failure to oscillate may be:

Weak or defective tube.
Open or shorted capacitor, C69.
Open grid resistor, pin No. 4 of V18.
Open cathode resistor, R88, or shorted cathode capacitor, C68.
Open plate loads, R87, R93, R94, or R91.
No B+, or low B+.
Shorted cathode (V18) to filament.

b. Blocking Oscillator. The same procedure may be used in troubleshooting the vertical sweep section containing a blocking oscillator (see Fig. 3-6). Check points in this circuit are:

Control grid of the oscillator, pin No. 7.
Plate of oscillator, pin No. 6.
Control grid of the amplifier, V104B, pin No. 2.
Plate of amplifier, pin No. 1.

The specified waveforms and amplitudes are shown in Fig. 3-6.

Failure of the oscillator to oscillate may be due to:

Weak or defective tube.
Open or shorted transformer, T103; or leakage between primary and secondary in this transformer.
Open hold control.
Open height control.
Shorted C135, C136.
Low B+.
Open B+ line.
No filament voltage.

If the picture will not hold and it is required to check for the presence of the sync pulse in the grid of the oscillator, it is necessary to remove the oscillator. Otherwise, the sync pulse will be lost in the normal oscillator grid waveform. If it is not possible to remove the oscillator, disconnect plate voltage thus "killing" oscillation. It is also possible to kill the oscillator by opening or shorting out the feedback path.

c. Plate-Coupled Multivibrator. In servicing the vertical sweep section of a receiver using a plate-coupled multivibrator, the same procedure is followed as was outlined for the receivers in Figs. 3-6 and 3-7. Specifically, refer to Fig. 3-8. The critical check points in this circuit are shown at points (A), (B), (C), and (D). The specified waveforms which should appear at these points are also indicated.

Loss of vertical synchronization may be due to any of the following causes:

Defective tube.
Absence of sync pulse: Check with a scope in the control grid, pin No. 2 of V114A. If there is a sync pulse present, it will be seen moving on the oscillator grid waveform at this point.
Change in value of C309, R313, and R314.

Failure of V114 to oscillate may be due to:

Defective tube.
Open capacitors, C309 or C308.
Open vertical hold or vertical height control.
Open plate-load resistors in V114A or V114B.
Shorted C317.
Open B+.

Figure 3-11 (DuMont Model RA166) illustrates a form of plate-coupled multivibrator more frequently used than the circuit of Fig. 3-8.

Troubleshooting this oscillator requires a slightly different approach from that previously used. The reason is that the vertical amplifier, V216, acts not only as the amplifier, but is also part of the oscillatory circuit. Hence, trouble in V216 will affect both amplifier operation and oscillator action. For example, the waveform which we would normally expect to find at test point (*A*) (grid, pin No. 6 of V213) may not be there if there is trouble in V216. Therefore, the signal-tracing sequence outlined previously may lead to erroneous conclusions.

Thus, if no waveform or an improper waveform appeared at (*A*), it would be necessary to measure voltages and/or resistances in both V213 and V216. If these voltages do not compare favorably with the manufacturer's rated voltages and resistances, they must be analyzed. Obvious conclusions as to the nature of the defective component may be drawn from the readings.

If a voltage and resistance analysis does not reveal the source of trouble, another technique may be tried. This presumes that V213 and V216 act as simple amplifiers which, by breaking the feedback loop, may be accomplished. Feedback is accomplished by C257 feeding the output of V213 to grid of V216, with R296, C258, R288, and C252 feeding the output of V216 back to the grid of V213. To break the loop, it is only necessary to open C252 by disconnecting the grid side of this capacitor. Now, a 60-cps filament voltage is fed through a 0.1-mf capacitor to test point (*A*). The sine wave then overdrives V213 and forms a sawtooth type of wave which can be traced through the vertical circuit. The amplitude of the filament voltage fed to the grid of V213 can be adjusted by connecting the grid to the center arm of a potentiometer (through a 0.1-mf capacitor) placed across the filaments. The input voltage is adjusted low enough

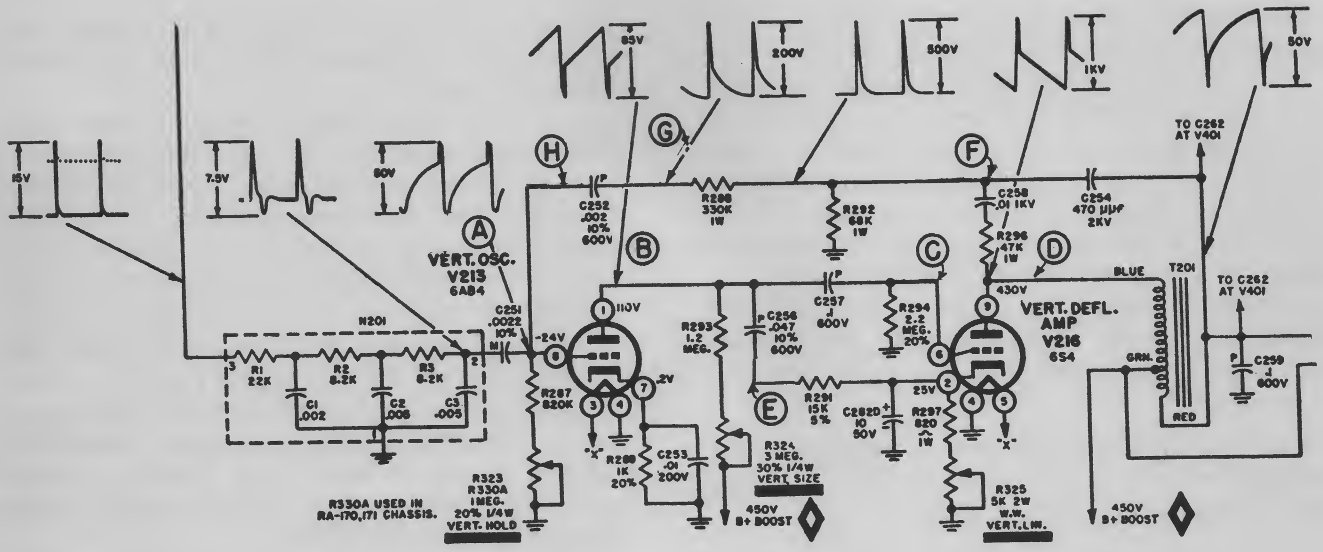


Fig. 3-11. Vertical sweep: DuMont RA 166.

not to overdrive either tube. The sine wave can be traced through the output tube to the yoke and will produce some vertical deflection on the screen if all the circuits are operating properly. The oscilloscope is used for tracing the progress of this test signal. It should appear at points (*B*), (*C*), (*D*), (*E*), (*F*), (*G*), and (*H*). Trouble is indicated in the coupling component or circuit where the signal fails to appear.

This technique may be similarly applied to any type of sweep oscillator.

4. Isolating Defective Part with VTVM or VOM

a. Procedure. When a signal fails to appear at the proper point in the scope-tracing sequence, trouble is indicated. This trouble lies in the circuit between the last check point, *P*1, where the signal appeared, and the point where it disappeared, *P*2. If the cause of trouble is not immediately evident, then it will be necessary to make a voltage and resistance analysis of this stage.

Note: In measuring voltages the technician should duplicate the conditions of the manufacturer's test set-up.

The set-up specified in the service manual includes: (1) The instrument used for measuring — VTVM or 20,000 ohms/volt meter. (2) Signal conditions at the antenna. (3) Line voltage. (4) Percentage of variation from normal which is still acceptable, usually 10 to 20 percent. (5) Any other specified conditions, such as setting of critical controls and ground return of meter.

TABLE I

	E Plate		*E* Cathode		*E* Grid	
Tube	Pin No.	Volts	Pin No.	Volts	Pin No.	Volts
V213	1	110	7	.2	6	−24
V216	9	430	2	25	6	0

b. Interpreting Voltage Readings. Table I is a chart of normal voltages in Fig. 3-11, using a VTVM, 117v a-c line voltage, and antenna input shorted.

Appreciable variations from these norms, and possible defects which may cause these variations, are:

Full boost B+ at plate, pin No. 1 of V213, means that no current is flowing through the tube. Otherwise, there would be an *IR* drop across the plate load. This may result from an open cathode or an open filament in V113.

No voltage at plate, pin No. 1 of V213, may result from:

Open vertical size control, R324.
Open R293.
Open boost B+ bus, or no boost B+.

Zero voltage at grid, pin No. 6 of V213, indicates circuit is not oscillating.

Positive voltage on grid, pin No. 6 of V216, indicates a leaky coupling capacitor (C257) or a gassy tube, V216.

Zero voltage at cathode, pin No. 2 of V216, indicates shorted capacitor, C282D, or cathode-to-filament short, defective tube, or no B+ at plate.

Low voltage, cathode, pin No. 2 of V216, indicates low emission in V216, or low boost B+, or leaky C282D.

High voltage at cathode, pin No. 2 of V216, indicates increased value in R297, R325, or open cathode resistor.

Low plate voltage at pin No. 9 of V216 indicates possible low boost B+.

Zero voltage at plate, pin No. 9 of V216, indicates possible open transformer, T201; or no B+.

c. Interpreting Resistance Readings. An analysis of voltage readings will point to a possible defective component such as an open resistor or shorted capacitor. A resistance test with power removed may confirm this possibility, but will not always bring out the defect. This is particularly true of situations where the component breaks down only under the application of voltage and returns to "normal" after voltage is removed. Replacement of the suspected component by a known good one is the procedure to be followed.

Note: In measuring resistance of components paralleled by resistors or coils it is necessary to open one end of component being measured.

5. DEFECTS IN VERTICAL SWEEP SYSTEM. Some of the common defects and their possible causes will be listed here.

a. Complete Loss of Height. Defective oscillator or amplifier tubes; open coupling capacitor; open output transformer; open deflection yoke; open feed-back loop in vertical oscillator; no B+; open plate-load resistors in oscillator; open vertical hold control or linearity control.

b. Insufficient Height or Vertical Nonlinearity. Weak output tube; low B+; low line voltage; increase in capacity of charge capacitor in output plate of oscillator; defective blocking oscillator transformer or open decoupling capacitor in B+ feed to vertical output transformer; defective output transformer; open cathode capacitor; defective linearity control.

c. Foldover. Low B+; low line voltage; leaky coupling capacitor between output plate of oscillator and grid of output amplifier; defective blocking oscillator transformer; defective output transformer; improper setting of height and linearity controls; weak output tube; open or shorted cathode bypass capacitor in output amplifier.

d. Loss of Vertical Sync. Defective oscillator tube; increase or decrease in frequency-determining time constant in oscillator; defective vertical sync circuits; defective blocking oscillator transformer.

e. Trapezoidal (Keystoning) Pattern. Shorted half of the vertical deflection yoke.

IV. COMPARISON OF HORIZONTAL SWEEP CIRCUITS

(Latest Receiver Models)

A. Horizontal Oscillator

The operational features of the horizontal oscillator are dependent on the type of synchronizing system employed. Basically, however, three main types are used:

Cathode-coupled multivibrator.
Blocking oscillator.
Hartley oscillator in conjunction with a discharge tube.

1. CATHODE-COUPLED MULTIVIBRATOR. The operation of the horizontal cathode-coupled multivibrator is basically the same as that of the vertical cathode-coupled multivibrator studied previously. Resistor and capacitor values are different in order to accommodate the faster time constants required by the higher horizontal frequency. Stability is increased by the addition of a ringing coil and capacitor in the plate circuit of the first triode section. This additional circuit, L14 and C65 (see Fig. 3-12) is shock-excited by the multivibrator action, causing it to oscillate at its natural frequency of 15,750 cps. The sine wave thus produced is superimposed on the multivibrator waveform.

Due to the fly-wheel effect of the ringing circuit, which operates at its natural frequency, the multivibrator action tends to maintain this frequency, although synchronizing of the control voltages might be temporarily disrupted. As in the vertical-type multivibrator circuit, the second tube remains cut off for the major portion of the cycle. This permits the capacitor, C68, located in the plate circuit, to charge up. The modified sawtooth wave formed by C68 and R92 is coupled to the output tube.

a. Identification. This type of circuit is readily identified by the common cathode resistor and the two-connection coil. The value of the cathode resistor is usually in the range of 1,000 to 3,000 ohms. The coil requires only two connections. Since it is not necessary for maintaining oscillation, it is possible in many instances to short out the ringing coil and still maintain a locked-in picture. This depends on the range of the horizontal hold control.

b. Control Voltage. The frequency control voltage is a low d-c voltage applied as a bias to the input triode section. This voltage is normally obtained from a phase detector circuit and applied through a suitable filter to the grid of the input triode.

c. Output Voltage. The output waveform No. 16, shown in Fig. 3-12, is at 15,750 cps and is for a normally operating circuit with +550v present at the boost B+ circuit.

2. BLOCKING OSCILLATOR. Once again, the similarity of oscillator operation can be compared with that of the vertical type. As in the cathode-coupled oscillators, the resistor and capacitor values are different, in order to allow for operation at the higher horizontal sweep frequency.

No. 14—6SN7—Hor. Osc. Plate
50V P-P 15,750 C.P.S.

No. 16—6SN7 Hor. Osc. Plate
135V P-P 15,750 C.P.S.

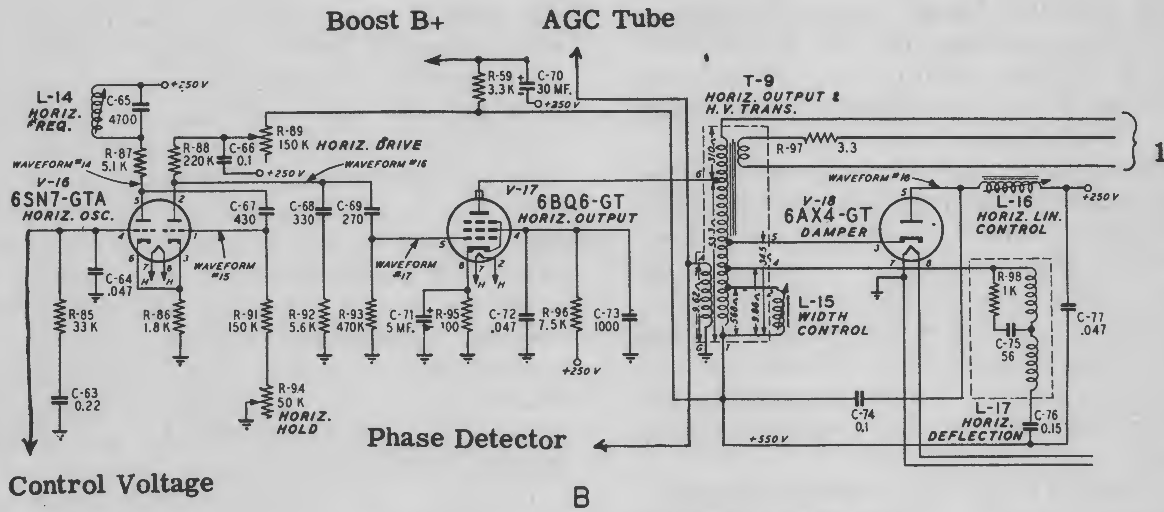
No. 18—6AX4—GT Damper Plate
120V P-P 15,750 C.P.S.

No. 15—6SN7 Hor. Osc. Grid
48V P-P 15,750 C.P.S.

No. 17—6BQ6 Grid
120V P-P 15,750 C.P.S.

No. 12—6AU6 A.G.C.
450V P-P 15,750 C.P.S.

A



B

Fig. 3-12. Horizontal sweep: Wells Gardner GS40.

The transformer used (refer to Fig. 3-13, winding A-C-F) is a slug-tuned autotransformer type. The slug tuning, which uses a powdered-iron core, provides a means for setting the coarse frequency adjustment so that a better range can be covered by the vernier or horizontal hold control. The additional winding C-D of the transformer is a stabilizing coil similar in operation to the ringing coil used in the cathode-coupled horizontal oscillator discussed previously. The combination of C309 with this coil

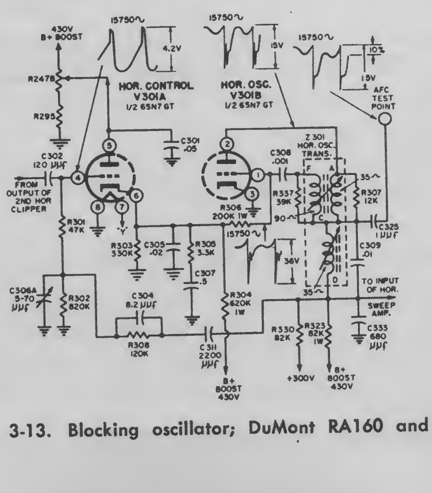


Fig. 3-13. Blocking oscillator; DuMont RA160 and 162.

is tuned to 15,750 cps by a powdered-iron core slug and is set at a point where noise pulses will have a minimum effect. As in the previous circuit, there is a capacitor in the plate circuit which forms the sawtooth wave, and this is coupled to the output tube.

a. Identification. This circuit usually incorporates a dual triode with one triode acting as the oscillator, as shown in Fig. 3-13, and the other triode as the control tube. The oscillator transformer is usually a four-terminal coil with an adjustment at either end. Some manufacturers separate the ringing coil from the oscillator section and mount the coils so that both adjustments are on the back panel.

b. Control Voltage. The triode control tube section regulates the oscillator frequency by changing the bias on the oscillator tube. This can be accomplished by feeding the control voltage to the oscillator cathode. The usual method is with a common cathode resistor. Control voltage can also be fed to the oscillator grid as shown in Fig. 3-13.

c. Output Voltage. This circuit is capable of producing a voltage large enough to drive an output tube. The voltage shown is for a normally operating circuit.

3. Hartley Oscillator in Conjunction with a Discharge Tube. Another common method of producing the horizontal drive voltage is by the use of a sine-wave oscillator and a discharge tube. The circuit in Fig. 3-14 shows a typical Hartley oscillator producing a sine wave at the grid of the oscillator tube. The frequency of the oscillator can be set manually by means of the tuning slug in the oscillator coil. A reactance tube coupled across the oscillator tank circuit maintains the proper frequency by electronically changing the effective reactance in the circuit. The oscillations produced on the grid bias the tube so that a distorted sine wave results at the plate. This is differentiated by C362 and R372, and the peaked pulse thus formed triggers the discharge tube. The charge-discharge network (C352, R365, and C356 in the plate circuit) creates the modified sawtooth wave, which is then coupled to the output tube.

a. Identification. This circuit stands out from the other horizontal oscillators because of the necessity of a discharge tube. A six-terminal (or greater) oscillator coil which incorporates a phasing adjustment may be used as in the RCA 630-type Synchrolock circuit, or a simple three-terminal coil as shown in Fig. 3-14 may be used. The oscillator tube may be a triode or a pentode. It is usual practice to wire the oscillator cathode to a tap or separate winding on the coil.

b. Control Voltage. The oscillator frequency is controlled by a small d-c voltage from a phase detector circuit. This voltage, which changes the grid bias, controls the amount of current flowing in the reactance tube; and thus, the effective amount of reactance is changed. The frequency can also be controlled by a tube acting as a resistance. The tube current is placed in series with a capacitor, C358

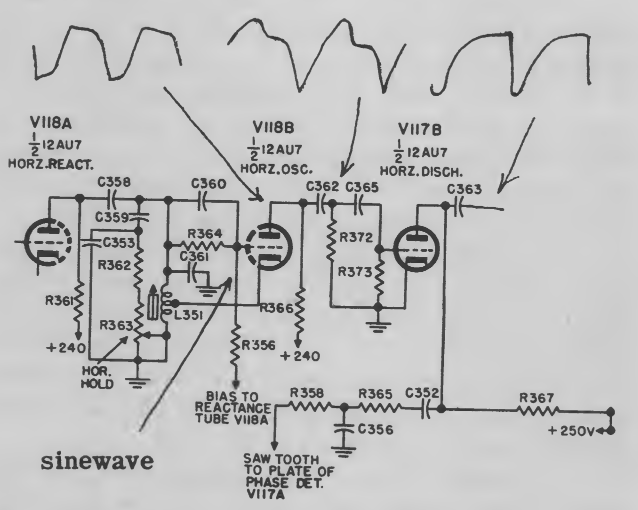


Fig. 3-14. Hartley oscillator: GE 21T1.

(Fig. 3-14) and placed across the tank circuit. A small d-c voltage at the grid can be used to control the tube effective resistance and thus change the oscillator frequency.

c. Output Voltage. The horizontal discharge tube delivers the voltage waveform shown in Fig. 3-14, which is the necessary drive for the output tube.

B. Output Circuits

This discussion is confined to magnetic deflection since electrostatic deflection is not used in present-day home-type receivers. The yoke supplies the magnetic force required to sweep the electron beam horizontally across the viewing screen. The yoke is mainly an inductive element, with some resistance due to the winding losses. Since an inductive element resists a change in current and a resistive element does not, a modified sawtooth arrangement is required to drive the yoke. It was this fact which necessitated modifying the waveform developed across the charge-discharge capacitor before coupling it into the output tube. The output tube, which is capable of passing high currents in its plate circuit, is biased by the signal. The signal drives the grid positive, which makes the grid draw current. This causes the grid coupling capacitor to charge up. The charge then leaks off through the grid resistor, creating a negative bias voltage on the grid. This condition further modifies the output waveform. In most receivers a bypassed cathode resistor is incorporated as a protective device, for if the drive signal should be lost, the voltage developed across the cathode would keep the tube from bing dstroyed.

The negative bias developed on the grid of the output tube supplies a good check point for trouble-shooting the circuit. This voltage may be from 10v to 40v negative, but will usually be about 18v to 25v. The limiting resistor in the cathode circuit supplies another good check point. The voltage here depends on the size of the resistor. Since the output tube draws approximately 100 ma, the cathode voltage should be approximately one-tenth the size of the resistor. Thus, 120 ohms will give approximately 12v positive.

The horizontal magnetic type of output circuits fall into three main categories. These categories, which refer to the means used to couple the yoke to the output tube, are

Transformer-coupled.
Autotransformer-coupled.
Direct-coupled, or direct drive.

1. Transformer-Coupled Output. Transformer-coupled output circuits have been and still are widely used. Refer to Fig. 3-15. Here a high-efficiency ferrite core transformer (T502) is used. The best impedance match consistent with fast retrace time and minimum

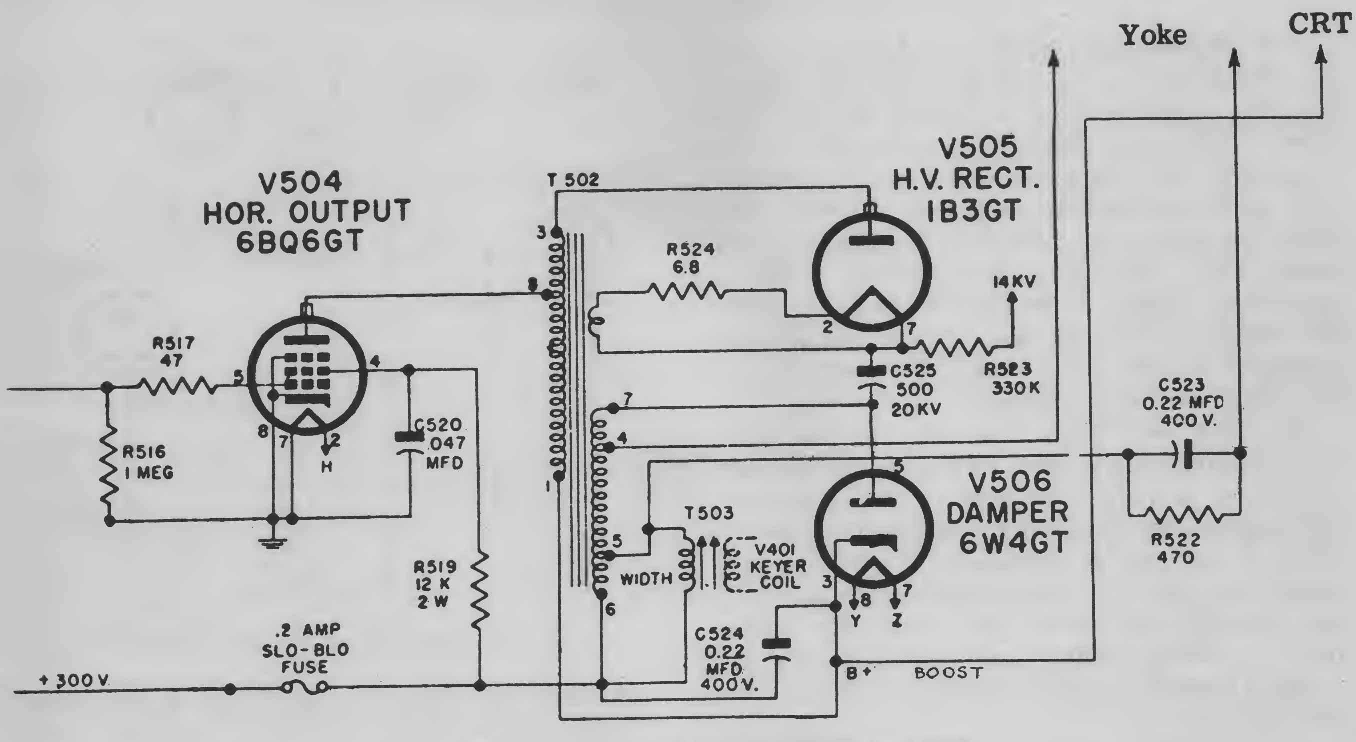


Fig. 3-15. Transformer-coupled output circuit: Capehart CX37.

ringing is obtained by coupling the yoke across pins No. 4 and No. 5 of T502.

The 6BQ6 output tube is driven into conduction by the waveform at the grid. This produces the necessary modified square waveform at the plate. The output tube is then sharply cut off by the negative pulse in the grid waveform, causing the magnetic field about the yoke to collapse. Thus, the beam is swept back from the right to the center of the screen. However, since the circuit is mainly inductive, the beam continues on its way until it reaches the left-hand side of the screen. This complete action is called the *return retrace* and must be complete in 7 microsec. The 15,750-cycle sweep means a 63-microsec interval. Therefore, the return trace must be completed in approximately 11 percent of the time interval. To accomplish this, the output circuit is designed to resonate at a little over 70 kc. This circuit is shocked into oscillation by sudden cessation of current at the end of the forward trace. In one half-cycle of the resonant frequency the beam is moved completely to the left of the screen. If not critically damped, however, the circuit would continue to oscillate. At this point, the 6W4 damper tube begins to function.

a. The Damper Tube. The damper tube is a simple high current-rectifying diode. It only conducts when the plate is positive with respect to the cathode. Immediately after the retrace, the damper tube starts to conduct. This action damps out the oscillation in the circuit as the beam is swept from the left-hand side of the screen toward the center. As this current flow starts to taper off (due to the charge on C524), the output tube comes out of cut-off and starts to conduct. The combination thus formed (see Fig. 3-16) creates a complete and linear sawtooth current wave in the yoke.

The damper tube also supplies boost voltage which is placed in series with the normal B+ voltage. This boost B+ voltage is used to supply the output tube so that its efficiency is increased. In many instances the boost voltage is used to supply other circuits, such as the vertical output circuit, the horizontal oscillator, or the focus or second anode of the CRT. The damper tube normally is placed in series with a capacitor, or with a capacitor and coil arrangement which constitutes the linearity circuit. The capacitor holds the kickback charge and maintains this voltage while the damper tube is not conducting. The coil and capacitor shape the waveform that exists at this point. By varying the inductance of the coil or the value of the capacitance, the waveform is varied. This affects the final current through the damper circuit, since the amount of current passed by the damper tube is dependent on the voltage existing across the damper at any instant. The linearity coil is adjusted to give linearly rising current through the damper.

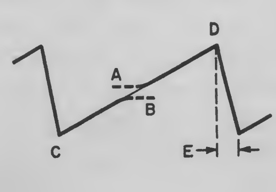


Fig. 3-16. Damper waveform: (A) output tube starts to conduct; (B) damper tube current tapers off; (C) left side of picture; (D) right side of picture; (E) return trace.

b. High-Voltage Supply. The kickback, or output, transformer is also used to supply the high accelerating voltage necessary to operate the CRT. The action is that of a simple autotransformer. At the instant that the output tube is cut off, the magnetic field in the transformer and yoke collapses. This causes a positive pulse to develop at the plate of the output tube. Through autotransformer action, a larger pulse appears at the plate of the 1B3 rectifier. The output transformer also supplies the filament voltage for the 1B3. This subject will be discussed in the section on "High Voltage."

The width coil, T503, adjusts the picture width. The coil inductance is reflected into the transformer. An increase in inductance causes a greater effective inductance in the transformer, thus permitting greater width. A decrease in inductance loads the transformer windings and causes a decrease in width. In some later receiver models the transformer inductance is varied by shifting half the transformer core so that a variable air gap is formed. This constitutes the width control.

Where electronic centering of the picture is used, a potentiometer with suitable bypassing is placed in the yoke return path in place of C523 and R522 (Fig. 3-15). By placing this potentiometer in a B+ path, it is possible to adjust the d-c voltage difference across the yoke. This permits electronic centering of the raster horizontally.

In order for the high side of the yoke winding to balance the distributed capacity of the low side of the yoke winding to ground, a capacitor or capacitor and resistor combination (Fig. 3-9, R541 and C528) is placed across the high side of the yoke. If this were not included, a slight ripple would appear on the left-hand side of the raster. There are some circuits where this distributed capacitance is automatically balanced, or where the two halves of the windings are in parallel. In these cases nothing is placed across the coils.

2. Autotransformer Output. The autotransformer type of coupling system operates on the same principle as does the transformer type. The closer coupling of circuits permitted in this arrangement creates a more efficient circuit with greater power transfer and reduced tendency to oscillate. In the autotransformer type of circuit (Fig. 3-12) the damper tube seems to be connected in reverse when compared with the previous hookup in Fig. 3-15. However, in this case (Fig. 3-12) the damper tube is located across what might be considered part of the primary circuit. Thus, the elimination of the usual transformer phase reversal produces the same effect with opposite hookup. The natural difference encountered here is that higher pulse voltages exist on the damper cathode. To prevent arc-over from filament to cathode, allowances are made in design. This takes the form of higher dielectric insulation in the filament supply winding or in the tube construction.

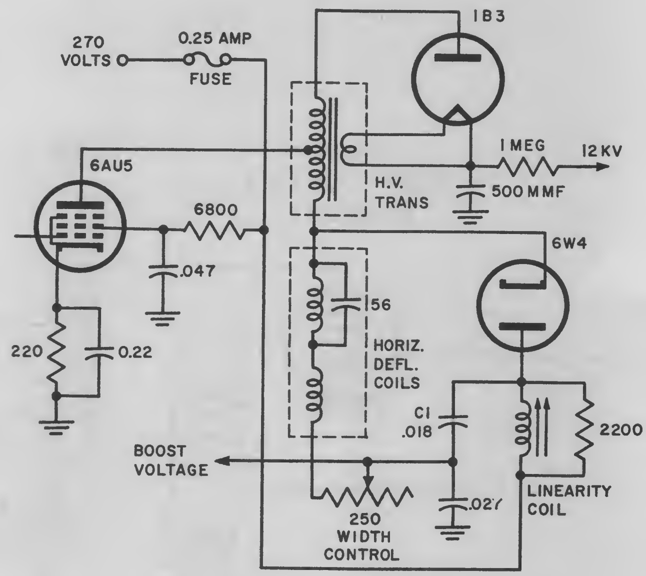


Fig. 3-17. Typical RCA direct-coupled output circuit.

3. Direct-Coupled, or Direct-Drive, Output. In the direct-coupled systems (Fig. 3-17) the yoke is placed in series with the transformer, which is usually an air-core type. The coupling which exists is simply the common current path of the two circuits. The basic circuit arrangement is similar to the autotransformer, but impedance values are different and are not interchangeable.

V. TROUBLESHOOTING THE HORIZONTAL SWEEP CIRCUITS

A. Visual Indications of Horizontal Sweep Defects

When the horizontal sweep circuits become defective, certain visual indications will be present. Although complete loss of raster can often be traced to the horizontal sweep circuits, it can also be caused by other circuits. However, this condition, accompanied by loss of accelerating voltage, localizes the trouble to the horizontal sweep and high-voltage circuits. Since excitation for the accelerating voltage is derived from the final stage of the sweep circuit, it is evident that the oscillator and output must be functioning to produce this voltage.

Loss of horizontal sweep with the presence of light on the screen indicates proper operation of the sweep circuit up to and including the output tube. The output tube must be operating to produce light on the screen.

A folded picture, which can normally be traced

to the damping circuit, might also be the result of an improper waveform at the grid of the output tube. Since this is so, it is obvious that improper linearity can also be caused by these two circuits. A keystoned picture or loss of horizontal sweep with high voltage still present is traced to the yoke circuit.

Components in the horizontal oscillator circuit can become defective and cause the horizontal oscillator to operate at an improper frequency. This condition shows up as multiple pictures intermixed horizontally, widely spaced ragged horizontal lines, or tilted horizontal blanking bars. Since the horizontal oscillator is usually an integral part of the horizontal control system, off-frequency operation usually does not signify horizontal oscillator trouble. If it is possible to adjust instantaneously for a single frame, then the oscillator shows that it can be brought into frequency. This localizes the trouble to the control section.

1. FREQUENCY AND FREQUENCY CONTROL ADJUSTMENTS. In order to obtain the correct operating frequency, all controls associated with frequency must be adjusted for their best range.

a. Cathode-Coupled Multivibrator

(1) Set horizontal hold control in the center of its range.

(2) Short out sync signal at grid of first oscillator triode.

(3) Where a horizontal range control exists, also short out ringing coil.

(4) Adjust range control until a single picture is obtained (picture need not be steady).

(5) Remove short across ringing coil and adjust ringing coil as in step 4.

(6) Remove short in sync circuit.

Step 2 may be omitted if the horizontal hold range is too close to one end.

b. Blocking Oscillator

(1) Set horizontal hold control fully clockwise.

(2) Adjust oscillator coil to give a single picture with the horizontal blanking bar near the center. If a ringing coil or a waveform circuit is used in conjunction with the oscillator coil, it may be impossible to sync picture at all unless the waveform adjustment on this coil is turned counterclockwise (out of coil), a few turns at a time, while trying to sync the circuit. In extreme cases the ringing coil may be shorted out (Fig. 3-13, pins *C* and *D*) while servicing this section.

(3) Turn horizontal hold control fully counterclockwise and throw picture out of sync. If necessary, switch off-channel or slightly turn oscillator coil adjustment to throw picture out of sync.

(4) Advance hold control slowly clockwise and note the number of horizontal blanking bars present before the picture pulls in. If more than three bars are present, adjust horizontal lock-in trimmer for greater capacity (clockwise); if less than two bars are present, adjust trimmer in opposite direction. Repeat this step until trimmer does not need adjustment.

(5) Waveform adjustment (when used) is made by connecting a low-capacitance probe or small capacity in series with regular probe of an oscilloscope to point *C* of the oscillator transformer. (Fig. 3-13). Adjust the waveform adjustment until equal peaks, or peaks as shown for this point in Fig. 3-13, are obtained. The picture should be maintained in sync at all times with the oscillator adjustment on the coil.

(6) Disconnect scope and repeat steps 1 and 2. Then the hold control should be adjusted until picture locks in. Connect scope again and check waveform. Repeat steps 5 and 6 until both conditions are met. If necessary, repeat steps 3 and 4.

c. Sine-Wave Oscillator

(1) Set horizontal hold control in the center of its range.

(2) Adjust horizontal frequency so that sync pull-in occurs equally spaced from the ends of the hold control. When synchronization occurs over entire range of hold control, adjust the horizontal frequency to obtain pull-in at equal spacing from the midpoint of the final adjustment. Pull-in occurs when pictures just come into sync after having been thrown out of sync.

(3) When a phasing coil is used, it is adjusted to center the picture on the raster. When improperly adjusted, the horizontal blanking bar can be present on the screen with a portion of the picture on either side of the blanking bar. For perfect adjustment the brightness control is advanced so that blanking does not blank-out the screen. Then the phasing is adjusted until equal amounts of blanking are visible on the sides of the screen. It will be necessary to shift the picture both left and right to view the blanking effect.

2. DRIVE, WIDTH, AND LINEARITY CONTROLS. The drive control determines the amount of signal which reaches the grid of the output tube. This must be adjusted with three things in mind.

a. Sufficient Drive. There must be sufficient drive to keep the output tube from destroying itself. The drive determines the amount of grid bias developed on the tube, and it must be high enough to keep the plates of the output tube from glowing red.

b. Proper Accelerating Voltage. The accelerating, or high, voltage is a function of the drive. Therefore, sufficient high voltage can be obtained only with the proper amount of drive.

c. Picture Linearity. The drive control usually affects the picture linearity by spreading the left-hand side of the picture.

With these three points taken into consideration, the drive, width, and linearity controls are adjusted to give a linear picture horizontally with the picture slightly wider than the mask. In some cases an auxiliary horizontal drive or peaking control is used. This is also adjusted for best linearity and width.

B. Troubleshooting Techniques

1. GENERAL. General procedure has been outlined in preceding text. Adjust controls associated with the defective circuit. This includes horizontal frequency, hold, waveform, phasing, lock-in range, drive, linearity, width, peaking, and centering, where indicated. However, the position of the controls should be noted so that they may be returned to their original settings if readjusting them did not clear up the trouble.

2. EQUIPMENT. The instruments used to troubleshoot the horizontal circuits in the shop include a tube tester, an oscilloscope, a VTVM, a crosshatch or video generator, and a capacity tester. These instruments have been discussed in a preceding section.

3. ISOLATING THE DEFECTIVE STAGE WITH A SCOPE. Unless the defect is obvious, the best method of localizing a trouble is by means of a scope. The waveforms can be traced from the horizontal oscillator to the sawmaker, to the output tube, to the deflection yoke, and the damper circuits. Thus, by allowing for the interdependence of the oscillator and its control circuits, and by referring to the manufacturer's data where necessary, the defective stage is easily located.

The dynamic signal-tracing method made possible by the use of a scope may be employed in different ways. It is possible to start at the oscillator circuits and work toward the deflection coils or to start at the deflection coils and work toward the oscillator. However, due to the high current involved in the output circuit, another method is desirable. In order to prevent excessive damage to the output tube, output transformer, and their associated circuits, the waveform on the grid of the output tube is investigated first. Thus, by one check the circuit is divided at a convenient point. If the proper waveform exists on this grid, then the oscillator and sawmaker sections are known to be in good order and the signal is traced toward the yoke. However, an improper waveform at this point gives cause for preventive measures before proceeding to trace the signal toward the oscillator. Since the grid signal provides some or all the bias necessary for the output tube, loss of, or greatly reduced, signal at this point creates the possibility of overload damage to the output circuit.

a. Damage Prevention. In this case, where it is possible, the output tube is removed from the set. Where series filaments are used, it is necessary to disconnect the B+ to the output circuit at some convenient point as soon as, or before, any component shows a tendency toward overload.

b. Improper Boost Voltage. Since waveform voltages at the grid of the output tube are sometimes dependent on the amount of voltage from the boost B+ source, proper allowances must be made. A defective output circuit can reduce the voltage of the grid waveform by not supplying the additional boost B+ voltage to the oscillator and/or sawmaker circuits. Therefore, if the shape of the waveform is correct but the voltage is not, a quick check of the B+ voltage on the oscillator and sawmaker circuits should be made before deciding which circuits are at fault.

c. Waveforms in Horizontal Sweep Section (Wells Gardner, Model GS-40). Critical check points for the horizontal sweep section are shown in Fig. 3-12. The waveform repetition rate is 15,750 cps. The scope frequency is set at 7,875 cps. The PP voltages given with the waveforms can vary approximately 20 percent. This is a cathode-coupled multivibrator with an autotransformer output circuit. Using the recommended procedure, the waveform at grid of output tube is investigated first (Fig. 3-12, No. 17). If no waveform exists at this point, it is advisable to remove the 6BQ6 from the receiver before troubleshooting the oscillator circuit. It is noted that the oscillator is a two-tube multivibrator. Therefore, the lack of oscillation can be caused by either triode section.

The proper waveforms (Fig. 3-12, No. 16 and No. 17) can exist, but at a reduced voltage, while waveforms No. 14 and No. 15 in Fig. 3-12 are correct. The waveform voltages No. 16 and No. 17 can be as low as 60v PP. If the boost B+ voltage is only 250v, the above readings indicate that the trouble is in the output circuit. This is due to the fact that the boost B+ is low when the output circuit is not functioning. Scope readings are taken at cathode of damper, No. 18, to check the output circuit.

4. VOLTAGE AND RESISTANCE CHECKS (Fig. 3-12).

a. After the defective stage is isolated, voltage and resistance measurements are made in the defective stage, to determine the defective component. If the output circuit is at fault, it is possible that resistance and voltage checks will not result in the discovery of the defective component. In this case, parts substitution or removal of components from the circuit can be tried, while making allowances for the parts removed.

Removal of the width coil from the circuit will permit proper operation of the receiver if the width coil was shorting under voltage. If a shorted deflection coil, C74 or C77, is the defect, they can be open-circuited, one at a time, with a resulting rise in boost

B+ and better waveforms at No. 18. The high voltage will increase sufficiently in most cases to provide light on the screen.

b. Oscillator Control Voltage. Complete loss of raster or inability to sync a picture momentarily with the horizontal frequency adjustment can be caused by improper control voltage on the oscillator tube. For this condition check d-c voltage on the control grid, pin No. 4 of the oscillator, or short this point to ground. If the control voltage is at fault, this temporary short makes it possible momentarily to sync a picture with the horizontal frequency adjustment.

5. Servicing Output Circuit. When servicing the output circuit, it is sometimes possible to isolate trouble in the damper circuit by a process of elimination. The damper tube (refer to Figs. 3-12, 3-15, and 3-17) is removed from its socket and a jumper is used to connect B+ voltage to pin No. 3, the cathode of the damper socket. This B+ is available at the high-voltage section fuse. Everything in the damper circuit, including the deflection and width coils, can then be disconnected from the transformer to see if the remainder of the sweep circuit operates. Proper operation should be evidenced by the presence of at least 60 to 70 percent of the normal high voltage.

A *shorted linearity capacitor* can be checked by removing the damper tube. As in many circuits (refer to Figs. 3-12, 3-15, and 3-17), a shorted linearity capacitor, C1, will feed B+ voltage to the boost circuit even though the damper tube is out of the circuit. Therefore, if this condition is suspected, remove the damper tube and check for voltage with a meter. If brightness with a folded picture appears only after the damper tube is removed, check the linearity capacitor for a short. If an electrolytic capacitor is used to bypass the boost voltage to B+, it can give the effect of a leaky capacitor in the linearity circuit. This occurs because B+ is fed through the capacitor, due to the fact that its polarity is incorrect when boost voltage does not exist.

6. Defects in Horizontal Sweep Circuit. Some common defects and their causes are listed here.

a. Complete Loss of Raster, with no (or low) high voltage. Defective oscillator, output, damper, or high-voltage rectifier tubes; improper control voltage on horizontal oscillator; open linearity or oscillator coil; open cathode plate or screen resistors; open or shorted coupling or charge-discharge capacitors; open hold or drive controls; open or shorted output transformer; shorted screen bypass capacitor, linearity capacitors, or deflection coil coupling capacitor; open fuse (where one is used); shorted width coil or deflection coil; shorted capacitor or open filament or decoupling resistor in the high-voltage section.

b. Insufficient Width or Horizontal Nonlinearity. Weak tubes; low B+ or line voltage; open cathode bypass capacitor on output tube; open, partially open, or partially shorted linearity capacitors, coupling capacitors, width capacitor, or screen bypass capacitor; defective output transformer, deflection coils, linearity coil, or width coil; screen resistor changes value; improper adjustment of horizontal width, drive, or linearity controls.

c. Foldover. Defective damper tube or damper circuit; leaky coupling capacitor; defective output transformer; open linearity capacitor; defective feedback coupling capacitor.

d. Ringing in Raster. Capacitor across high side of deflection coil open, missing, wrong value, or erroneously placed across low side of winding.

e. Trapezoidal Pattern (Keystone). Shorted capacitor across high side of deflection coil or a shorted winding on the deflection coil.

f. Arcing. Sharp edges in the high-voltage section; defective deflection coils, output transformer, damper tube or filament winding that supplies damper tube; 500-mmf capacitor, voltage doubler or decoupling resistor in high-voltage supply; insulation, or tube sockets.

g. Improper Frequency and Loss of Horizontal Sync. Defective oscillator or oscillator control tubes; defective sync circuit; change in value of frequency-determining components, such as oscillator capacitors, resistors, frequency controls, and oscillator coil; improper adjustment of controls, including waveform adjustment of blocking oscillator.

VI. HOME SERVICING TECHNIQUES FOR THE SWEEP SECTION

A. Instruments Used

Generally, the technician carries few instruments with him on the home service call. There are, of course, variations in this practice. Some companies provide a service truck completely equipped with all test instruments. Some technicians come to the home with just replacement tubes. However, most technicians carry these instruments into the home:

1. 20,000 ohms/volt meter and/or VTVM.
2. Complete stock of replacement tubes.

Some technicians have expressed a preference for the VOM over the VTVM because it requires no external source of power and is light and compact.

B. Home Servicing of the Sweep Circuits

1. Preliminary Steps. If trouble is indicated in the sweep circuits, the technician follows the procedure previously outlined; namely,

a. Visual check, for obvious defects.

b. Adjustment of operating controls in the section affected.

c. Changing tubes.

2. Instrument Testing. If none of the foregoing procedures clears up the source of trouble, it will be necessary to take the chassis out of the cabinet for servicing in the home or for removal to the service shop. If possible, it is, of course, preferable to make the repair in the customer's home.

a. Vertical Sweep. If the trouble is in the vertical circuits, the following techniques are suggested for isolating the trouble to a specific stage:

(1) A 60-cps filament voltage can be applied through an 0.01 — 600-v capacitor wired up as a clip lead probe, to the grid of the vertical output amplifier. If the amplifier, output transformer, and deflection yoke are operating properly, vertical deflection will appear on the TV screen. Otherwise, there will be no deflection. If the output circuits are functioning properly, the trouble is in the vertical oscillator, and the VOM can be used to check voltages and resistances in that circuit. Otherwise, trouble is in the output circuits, and the VOM is used to probe these and the power supply.

Note 1. The technician should take with him a schematic diagram with manufacturer's ratings of voltages and resistances. The diversity of receivers and circuits makes this a necessity for rapid, efficient servicing. There is a prevailing prejudice among some technicians against taking service literature into the home. They fear that the customer will think they don't know their business. However, the continued use of service literature in the home by topnotch technicians disproves this fear.

Note 2. Suspected open capacitors can be bridged with equivalent value, known good capacitors. Suspected leaky capacitors can be tested in the home by disconnecting the low-voltage end and measuring d-c voltage from the open end to ground. A good capacitor will show a very slight voltage due to its high leakage resistance. A leaky capacitor will show an appreciable voltage, 2v or more, depending on the B+ source and the size and state of the capacitor.

Note 3. With a VTVM, it is possible to check for negative voltage in the grid of the vertical oscillator tube. A VOM will load the circuit and a smaller voltage will be read.

It is possible to use the VOM as an output meter and read an a-c voltage, under normal operation, in the plate of the oscillator, grid of the vertical output tube, plate of the output tube, and secondary of output transformer. This is an additional method of signal-tracing the vertical sweeps.

(2) Still another method of signal-tracing the vertical sweeps involves the capacitor probe mentioned above and the use of the audio circuits of the TV receiver as an indicator. The probe is connected from the plate of the oscillator tube or grid of the output tube to the input of the audio amplifier (top of volume control). If the oscillator is operating properly, a loud 60-cps buzz will be heard. If it is not, none will be heard. It is possible to follow the progress of the signal through the vertical sweep circuits in this fashion. Varying the vertical hold control will vary the pitch of the sound.

(3) A combination of methods 1 and 2, just described, can also be used. The filament voltage is used as the signal source, with the audio stages of the receiver or the output meter as the indicator. The signal can be introduced right at the integrator input to the vertical oscillator and its progress traced through the vertical oscillator and vertical amplifier. Loss of signal indicates trouble.

Note 4. The signal-tracing methods just described are effective in isolating the source of trouble when there is complete loss of vertical deflection due to component breakdown. However, their application is limited in cases where insufficient height or loss of synchronization is the trouble.

b. Horizontal Sweep. The horizontal circuit provides the excitation for the high-voltage supply in most TV receivers. Hence, horizontal troubles may also give rise to loss of high voltage. A blank screen results. The same condition might also arise from a defective high-voltage supply or a blown fuse. A blank screen might also indicate a defective CRT or improper biasing (brightness control and its associated circuit) of the CRT, or improper adjustment of the ion trap. It is therefore necessary to determine which of these is the trouble when there is no light raster on the CRT.

It is easy to determine whether or not there is high voltage. The technician should carry with him a high-voltage probe for his VOM or VTVM so he can measure the high-voltage output. If there is sufficient voltage, then the trouble lies in the CRT and its associated circuitry. If there is no high voltage, the trouble may be in the sweep or high-voltage circuits.

If there is a high-voltage fuse, this is checked first for continuity. If open, the cause for this is investigated and corrected, and then a good fuse is inserted. (Defective damper tubes frequently cause high-voltage fuses to blow.)

If the fuse is OK, the technician can check the output of the horizontal oscillator. If this is operating

properly and the coupling capacitor is good, negative voltage should be developed in the grid of the horizontal output tube. This can be checked with a VOM. No voltage at this point may be due to output tube loading of the signal in the grid. The screen grid of the horizontal output tube may be shorted to ground momentarily while checking for negative voltage on the signal grid. This eliminates the loading effect of the plate circuit, and a negative voltage in the signal grid would indicate that the oscillator is operating. As an additional check, the output tube may be removed (*first shut off the set*) and the a-c voltage checked at the grid of the output tube. If the horizontal oscillator is operating properly and the coupling capacitor is good, an a-c voltage will be measured.

If the indications are that the horizontal oscillator is not operating, that circuit is investigated with the VOM or VTVM. Voltage and resistance readings should lead to the source of trouble.

If the indications are that the horizontal oscillator is operating properly, the source of trouble is in the horizontal output circuit, damper circuit, high-voltage circuit, or deflection yoke.

In the horizontal output tube cathode and screen voltage checks may be safely made with a VOM. Do not attempt to read d-c voltage at the plate, because of the high a-c pulse which appears there.

However, by temporarily disconnecting the plate cap (with power removed) from the horizontal output tube, it is possible to measure the d-c voltage at the cap through the primary of the output transformer.

A circuit analysis should lead to the defective component, where abnormal voltages and/or resistances are found.

Note 5. If there is no negative voltage at the control grid of the horizontal output tube, it is best to remove the horizontal output tube at once. The excessive current the tube is drawing may damage it.

Note 6. It is well to remember that it should be possible to read a-c on an output meter, wherever a sweep pulse is present, unless the meter loads the circuit to the point where there is no indication. A VOM has a low ohms/volt rating on the a-c scale. A VTVM has a high ohms/volt rating. With a VTVM, it is possible to trace the a-c sweep signal everywhere except at the plates of the horizontal output tube and output transformer. There, the a-c pulse exceeds the rated input for the meter.

Note 7. Indications by high-voltage arcs: When there is no raster present on the screen, a high-voltage probe should be used to check for high voltage. It is also possible to check for high voltage by momentarily arcing the anode lead to ground. The anode lead should not be shorted to ground but should be brought near it. This method, however, should be used with care to avoid shock when high-voltage is present. Moreover, if voltage is present, a continuous d-c arc will place an excessive load on the rectifier tube and the filter resistor. This method is dangerous and should not be used with a 60-cps high-voltage supply.

If there is no d-c arc, an insulated screwdriver can be used to draw an a-c arc from the rectifier or output tube plate. The a-c pulse voltage present creates a corona discharge to the screwdriver when it is brought near. The screwdriver should not be grounded, since d-c voltage is also present at these plates.

A short in the high-voltage circuit may ground out the high voltage and cause no indication to be present at the plate caps. To check for this condition, disconnect (with power off) the high-voltage rectifier plate cap and suspend it in midair. Now, with power "On," a corona arc can be drawn from the suspended cap if the sweep circuit is operating.

When the above checks show no arcs, it is possible to check the circuits prior to the plate of the output tube. Disconnect the plate caps from both the rectifier and the output tube. The plate cap which originally went to the rectifier tube is connected to the plate of the output tube. Let the original output tube plate cap be suspended in midair, turn on the set and check at the plate of the output tube for a corona discharge to a screwdriver. A large corona discharge at this point indicates that all the circuits previous to the transformer are functioning. It is also possible that a defective primary in the output transformer will not permit a corona discharge, even though the circuits prior to the plate of the output tube are operating properly. In this case, a test transformer may be substituted.

VII. PARTS REPLACEMENT REQUIREMENTS

A. Exact Replacements

Some components in the sweep section require exact replacements for proper operation of the circuit. These include the inductive components and temperature-compensated capacitors and/or resistors.

1. Blocking oscillator transformer.
2. Vertical output transformer.
3. Horizontal output transformer (flyback).
4. Deflection yoke; associated coils.
5. Temperature-compensated capacitors and/or resistors.

In general, a replacement for any of these components must have the same electrical characteristics as the original.

Physically, it should be the same size and shape with an equivalent mount, so that the technician will not have to spend time drilling and making other changes. Occasionally, it may be necessary to make some physical modifications where an exact equivalent is not available.

B. Sources of Replacement Information

The best procedure to follow is to secure a direct replacement. For this purpose manufacturers publish parts lists. Each part is identified by a specific code number. These lists are available from the manufacturer's distributor or from his parts distributor.

If a direct replacement is not available, the technician must seek an equivalent. Parts manufacturers publish TV replacement guides for the components in the sweep circuits. These identify the proper replacement for a particular manufacturer's specific parts. However, these are not always exact replacements, and time-consuming modifications may be required. The technician should look for any notes or other specifications indicating the need for such modification.

Some replacement guides are now also published commercially along with service information.

C. Critical Component Considerations

1. VERTICAL SWEEP CIRCUITS. The reason for caution in securing exact replacements is indicated in this partial tabulation of specifications of one manufacturer for a vertical blocking oscillator transformer.

a. Vertical Blocking Oscillator Transformer. The exact transformer required is determined by the tube type and other circuit constants.

b. Vertical Output Transformer. The important characteristics identifying a proper replacement for a vertical output transformer are:

Turns ratio (most important).

Primary impedance and current rating.

D-C resistance.

Physical characteristics such as size and mounting.

Conventional and autotransformers are used in vertical output circuits.

2. THE HORIZONTAL SWEEP CIRCUITS. When replacing defective parts in the horizontal sweep circuit, only exact replacement parts or direct substitutes may be used in the critical circuits. The oscillator circuit must be able to maintain its frequency at all times. To accomplish this, component parts that are stable through heat and time changes must be used for the frequency-determining elements. Comparatively small changes in capacitive or resistive values in the oscillator circuit will cause sufficient change in the frequency to prevent the frequency control systems from maintaining a locked-in picture.

TABLE II

Part No.	Turns Ratio Pri.:sec.	Mtg. Centers (in.)	Mtg. Type
A-11	1:4.2	2	A
A-21	1:4.2	1 15/16	TD
A-22	1:4.2	1 13/64	TS
A-24	Sec. No. 1, 1:0.48	2 3/8	A
	Sec. No. 2, 1:1		
A-25	1:4.2	1 3/4	A
A-26	1:1.5	1 3/4	S

a. The output section is a power amplifier, and as such, passes large quantities of current. The cathode and screen resistors must therefore be capable of dissipating the necessary wattage. The output circuit is also fused. The fuse rating usually allows up to a 100 percent overload factor, and this should not be increased. However, a Slo-blow fuse of the same value may be substituted to allow for an instantaneous surge.

b. The horizontal output transformer and yoke are matched units. When improperly matched, the retrace time, ringing, linearity, and size can be affected. Very often, width coils, agc, and afc transformers are used in conjunction with the horizontal output transformer. The impedances of these units must be properly matched.

c. Horizontal Output Transformer (Flyback). There are many different types of circuits involving different functions and arrangements. It is necessary to ask for a replacement by a number taken from a reliable catalog or guide.

3. DEFLECTION YOKE. The important characteristics are:

The inductance of the horizontal and vertical ections.

The deflection angle.

Core material.

Physical characteristics.

Method of winding (such as cosine).

It is interesting to note that most receivers using from 16- to 21-in. CRT's use deflection yokes rated at 66- to 70-degree deflection angle. Therefore, it is hardly sufficient to ask for a 70-degree yoke and expect a proper replacement. The technician might get any one of ten different types, and it might not be the proper replacement.

4. Temperature-Compensated Capacitors. These are a group of capacitors exhibiting certain temperature characteristics. They vary from capacitors with negative coefficients (that is, those which exhibit a decrease in capacity with an increase in temperature) to capacitors with zero coefficients (most stable of all), and capacitors with positive coefficients. The degree of change of capacitance under rated conditions is given by an index number, such as N750. This is a negative temperature-compensated capacitor whose capacity decreases 750 parts per million per degree C of temperature increase.

Temperature-compensated capacitors are mainly ceramic. They are found in frequency-sensitive circuits such as the capacitor across the stabilizing coil in a horizontal oscillator. Where used, they are or should be identified as a special part in the manufacturer's parts list. Exact replacements are required.

D. Other Replacements in Sweep Circuits

1. Capacitors. These are rated for capacitance, tolerance working voltage, operating temperature, peak voltage, insulation resistance, losses, type of dielectric, and physical shape and size. In general, equivalent replacements should be made. Capacitors should not be underrated for voltage. Mica and ceramic capacitors have highest leakage resistance. Molded paper capacitors are replacing regular paper capacitors, because of their longer life and stability.

The technician should note that, in addition to the 20kv high-voltage filter capacitor, there are other high-voltage capacitors in the horizontal sweep circuits. Thus, across the high end of the horizontal deflection yoke, there is usually a 50-mmf, 2,000-v capacitor; a 20- to 50-mmf capacitor rated at 6,000v, in the damping circuit of a direct-driven horizontal deflection yoke; and 0.033 to 0.1-mf capacitors at 1,000v across linearity coils.

An obvious rule to follow is to check the voltage rating shown on the capacitor body or to consult the parts list.

2. Resistors. Resistors are rated for resistance, composition, wattage, tolerance, body insulation, and physical shape and size. Equivalent replacements should be made wherever possible. Replacements should not be underrated for wattage.

E. Replacement Techniques

A frequent customer complaint is that "the technicians do a sloppy job and run out before it's finished." Closer questioning usually reveals that, when putting the chassis back into the cabinet, only one screw was used instead of the usual four, or that the technician did not screw in all the retaining screws on the dust cover. This type of carelessness leads to poor customer relations. It is also a source of potential danger because it leaves the set exposed.

This also points up the need for using proper care in replacing large or small components in a TV receiver. Good rules to follow are:

1. Transformers or other hardware-mounted items should be properly secured with the right number of screws, lockwashers, and nuts. Loose mountings can, and often do, lead to functional breakdown.
2. Replaced parts, such as resistors and capacitors, should be mounted in the same position as they were originally. Similarly, lead dress in the sweep circuit may be critical, and interaction might result if leads were not properly placed.
3. Parts should be replaced with direct replacements wherever possible.
4. Leads should be kept as short as possible.
5. High-voltage leads should be properly insulated (20kv breakdown) and should be kept off the chassis.
6. Broken socket pins should be replaced when possible. Low-loss, well-insulated sockets should be used where socket replacements are required for the damper and high-voltage rectifier.
7. Inferior or underrated components should never be used. They invariably break down and lead to recalls.

F. Preventive Maintenance

Of all the services that the modern TV service shop offers to its customers, preventive maintenance is the least emphasized. The reason usually given is that the customer wants only repairs that correct the trouble which caused the set to break down and will not pay for any "check-up."

This type of reasoning ignores the vast experience of other service industries, where check-up is an accepted service for which the customer is glad to pay. One example, of course, is the automobile service industry. And yet, in its infancy (somewhat like the present youthfulness of the TV service industry) the automobile service industry raised the same objections to selling preventive maintenance as a "service."

As a start in this direction, the following minimum suggestions are offered:

1. Every set which has been serviced in the shop should be given an air check, and then permitted to operate for several hours or longer, depending on the nature of the trouble. Intermittents may require "cooking" for several days.
2. Every chassis should be thoroughly cleaned with a blower and vacuum before it leaves the shop. The high-voltage cage, particularly, collects metallic dust. This may cause arcing and breakdown if not cleaned out.
3. The technician should check for evidence of burned insulation in the high-voltage cage and the lead going to the anode cap. A high-voltage sleeve

should be placed on this lead if necessary.

4. The high-voltage and damper tube should be tapped gently with a rubber-tipped pencil or a screwdriver, for evidence of loose elements.

5. The hold controls should be set in the middle of their range. This involves adjustment of associated sync controls.

6. The sensitivity of the sweep circuits should be checked. This involves checking for proper height and width. Can the raster fill the entire screen adequately without having the width, height, and linearity controls turned to their full range? If the controls are at maximum, or if the raster is too small, the tubes in the appropriate stages should be tested and replaced if weak.

7. Resistors associated with shorted bypass capacitors should also be replaced.

8. The area around the high-voltage cap should be cleaned with a dry cloth.

9. The ion trap should be readjusted for maximum brightness.

10. If the horizontal output tube plates are overheating (getting red), determine the cause and correct it.

CHAPTER 4. HIGH-VOLTAGE SERVICING

I. HIGH-VOLTAGE OPERATION

A. Function of the High-Voltage Section

This section generates the high d-c voltage required to accelerate the electron beam of the CRT so that it will have sufficient energy upon striking the screen to cause it to fluoresce brightly.

B. Components of the High-Voltage System

Present-day TV receivers use, almost exclusively, the flyback type of high-voltage system. In this arrangement the horizontal output transformer also acts as a high-voltage autotransformer and supplies a 15,750-cps high-voltage pulse to the high-voltage rectifier. This pulse is generated in the output transformer when the output tube current is cut off during retrace time. The horizontal output tube is fed by the horizontal oscillator, or sawmaker. Breakdown in the horizontal oscillator, output amplifier, output transformer damper, or high-voltage rectifier and its associated circuits may result in complete loss of, or reduced, high voltage. For troubleshooting purposes it is therefore necessary to include as part of, or related to, the high-voltage system all the stages of the horizontal sweep section and the high-voltage section.

C. Circuit Comparison (Recent Receiver Models)

1. General. Similarities in the high-voltage rectifier circuits outweigh the minor differences. Present-day trends are for the use of:

a. A single tube wired up as a half-wave rectifier,

b. Two tubes acting as a voltage doubler, or

c. Three tubes acting as a voltage doubler.

Of the receivers analyzed, 90 percent utilized the single-tube hookup and 10 percent made use of the voltage-doubler arrangement.

All but one of the receivers contained a small limiting resistor (range from 0.56 to 6.8 ohms) in the rectifier filament circuit.

Filtering of the high-voltage supply was accomplished in most cases by a simple 500-mmf high-voltage capacitor. This was either the familiar button type or the capacitance between the internal and the external coating on the CRT. Only 10 percent of the receivers included a filter resistor in series with the hot high-voltage lead.

In 70 percent of the models, the 1B3 was used as the high-voltage rectifier. Twenty percent used the 1X2A and the remainder the 1AX2. (*Note*: The 1X2A and the 1AX2 are not interchangeable.) High-voltage output varied from 13kv to 17.5kv.

2. Single Tube Used as Half-Wave Rectifier. Refer to Fig. 3-15 for the circuit diagram of the Capehart CX-37 horizontal output and high-voltage section. V505 (a 1B3) is used as the rectifier, whose plate receives the high-voltage 15,750-cps pulses from the primary winding of the horizontal output transformer in the plate of V504 (the 6BQ6). This winding acts as an autotransformer and steps up the a-c pulses applied to the rectifier plate. The high-voltage filter consists of C525, a 500-mmf, 20kv capacitor, and R523 (a 330 K resistor) in series with the hot lead going to the anode on the CRT. R524, a 6.8-ohm 2-watt limiting resistor, is used in the filament of the 1B3. The filter capacitor, C525, is returned to the damper plate rather than to ground, adding to the high-voltage output the voltage found at this point.

3. Two-Tube Voltage Doubler. Figure 4-1 is the schematic diagram of the DuMont RA-160 high-voltage section using a two-rectifier cascade voltage doubler. Excitation for these tubes again comes from the autotransformer section of the horizontal output transformer in the plate of the horizontal output tube. The output of this conventional voltage doubler is 16kv $\pm$ 2kv. The output voltage is distributed between C318 and C319 10-kv capacitors. The network of 470 K 2-w resistors (R318, R319, R320, and R321) supply the d-c path for charge on C317 from C319. A trouble commonly found is breakdown of these resistors due to internal arcing. R317 and R322 are 3.6-ohm filament-limiting resistors.

Operation of the circuit is as follows:

A positive high-voltage pulse at the plate of V303 causes that rectifier to conduct, charging C319 to the peak of the 15,750-cps pulse. After the pulse has passed and until the next pulse appears, C319 charges up C317 through the network consisting of R318 through R321. C317 does not charge quite up to peak voltage because of the losses introduced by the resistor network. When the next high-voltage pulse appears, its voltage is in series with the voltage in C317. Thus, V304 sees a voltage somewhat less than twice the pulse appearing from the horizontal output transformer. V304 conducts and capacitors, C319 and C318, charge up to a value slightly less than twice the peak a-c voltage pulse. The high-voltage d-c output is taken from the filament of V304.

4. Three-Tube Voltage Doubler. Figure 4-2 is the schematic diagram of a three-tube voltage doubler used in the 21-in. GE Stratopower chassis. It is excited in the same manner as were the previous high-voltage circuits. V121, V122, and V123 constitute the three rectifiers. The 16-kv d-c output is taken from

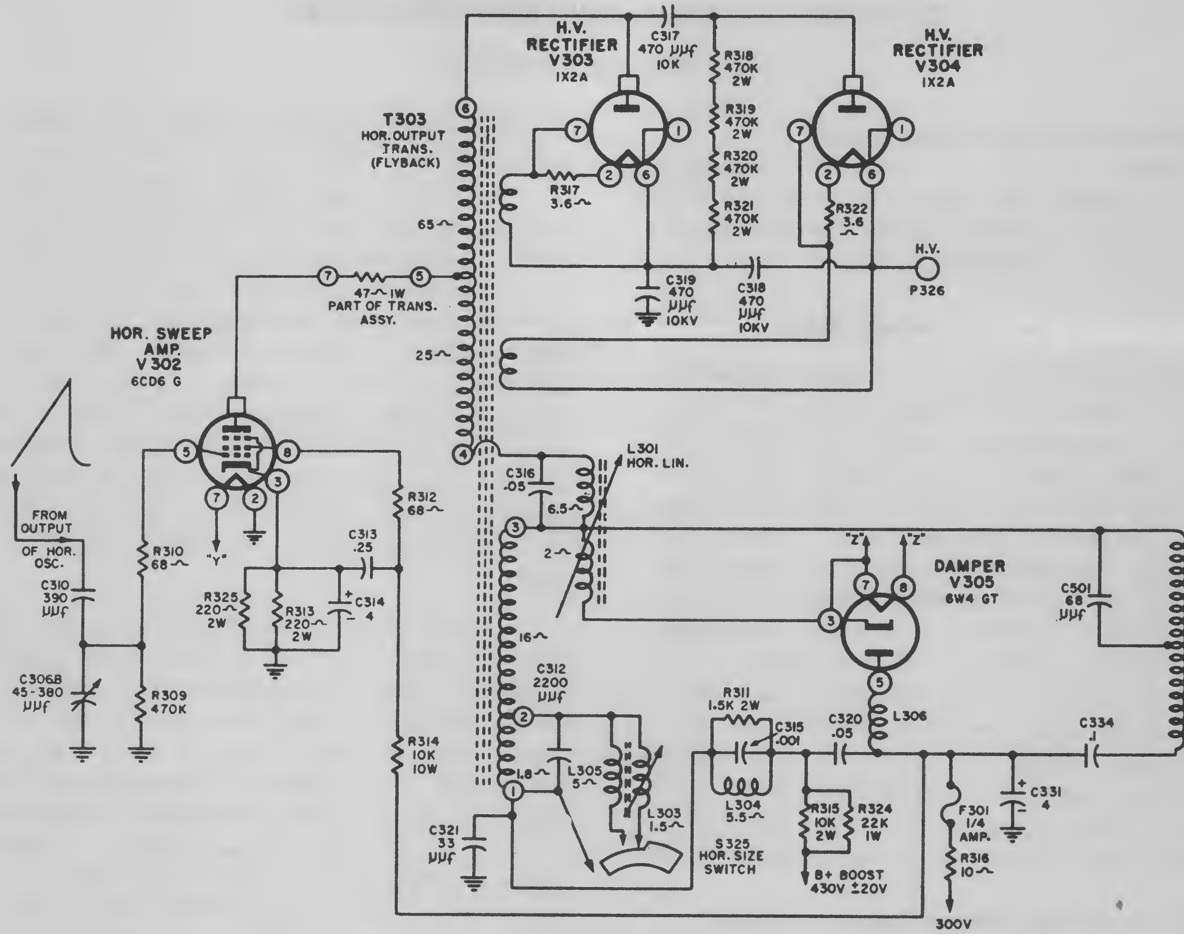


Fig. 4-1. High-voltage supply and horizontal output: DuMont RA160.

the filament of V123 and fed to the CRT accelerating anode. The inner and outer coatings of the CRT act as the high-voltage filter capacitor.

Operation of the circuit is almost the same as that of the conventional doubler. V121 and V123 take the place of V303 and V304, respectively, in Fig. 4-1. V122 replaces the resistive network of R318 through R321. This substitution eliminates the possibility of resistor arcing and also eliminates the losses dissipated by the network. In this manner an extra 1kv previously lost is made available to the circuit.

Circuit operation of V122 is as follows: C378 charges through V121 to about 8kv, when the high a-c positive pulse appears at the plate of V121. C379 then charges up to the voltage on C378 through V122. The next high-voltage pulse is in series with the charge on C379, and the combined voltage charges up the capacitor on the CRT to 16kv as V123 conducts.

In replacing the resistive network with V122 (in the case of the GE receiver), V122 eliminates the following losses:

a. Power loss dissipated in the resistive network when C378 charges C379.

b. Power loss introduced by the resistive network which is in series with the output load current.

5. Identifying Characteristics. The half-wave nondoubler high-voltage circuit is characterized by the use of a single rectifier operating off the autotransformer winding of the horizontal output transformer. The high-voltage filter capacitor is usually rated at 500 mmf 20kv.

The two-tube doubler uses two half-wave rectifiers in cascade, with separate filament windings for each of these rectifiers. The high d-c voltage output is distributed across two series capacitors, each rated at half the voltage normally required by the filter used in the single half-wave rectifier circuit.

The three-tube doubler uses three rectifiers. Two of these perform in the same fashion as those in the two-tube doubler. The third rectifier replaces the resistor network found in the two-tube doubler. Three separate filament windings are required for the three rectifiers.

6. Troubles in the High-Voltage Supply

a. No high voltage, due to defects in horizontal sweep system. Breakdown in the horizontal sweep system eliminates the excitation (high-voltage a-c

pulses) at the plate of the rectifier.

b. No high voltage or reduced high voltage when high-voltage ac is present at the plate of the rectifier. This condition may arise from:

(1) Defective rectifier tube.

(2) Open filament resistors.

(3) Open filter resistors, or resistors whose value has increased greatly.

(4) Open resistors in doubler network.

(5) Shorted high-voltage filter capacitors.

(6) Defective rectifier tube socket carbonized, due to arc-over.

(7) Defective horizontal output transformer whose insulation has melted from excessively high heat.

(8) High-voltage rectifier filament winding shorted to ground.

(9) Core arcing in horizontal output transformer.

(10) Arcing and corona due to burned-out insulation of the sleeve on high-voltage wire going to CRT anode.

(11) Arcing due to deposit of metallic dust in high-voltage cage.

II. TROUBLESHOOTING THE HIGH-VOLTAGE SECTION

A. Control Adjustment and Equipment Required

1. Controls. The controls associated with this circuit are discussed under "Horizontal Controls" in the horizontal sweep section. Controls affecting horizontal drive or frequency will directly affect the high voltage. The circuit constants are designed to operate close to 15,750 cps. Therefore, a large frequency change will cause transformer efficiency to fall off and resistor and capacitor time-constant values to produce insufficient drive and insufficient high voltage.

2. Equipment Required. The instruments used to troubleshoot the high-voltage section include a tube tester, a VTVM, a high-voltage d-c probe, a scope, a high-voltage a-c probe, and a capacitor checker.

B. Visual Indication of Circuit Defects

Trouble in this section is readily identified by its effect on the raster. These symptoms may be attributed to high-voltage troubles:

1. Dark Screen, due to total loss of or reduced high voltage.

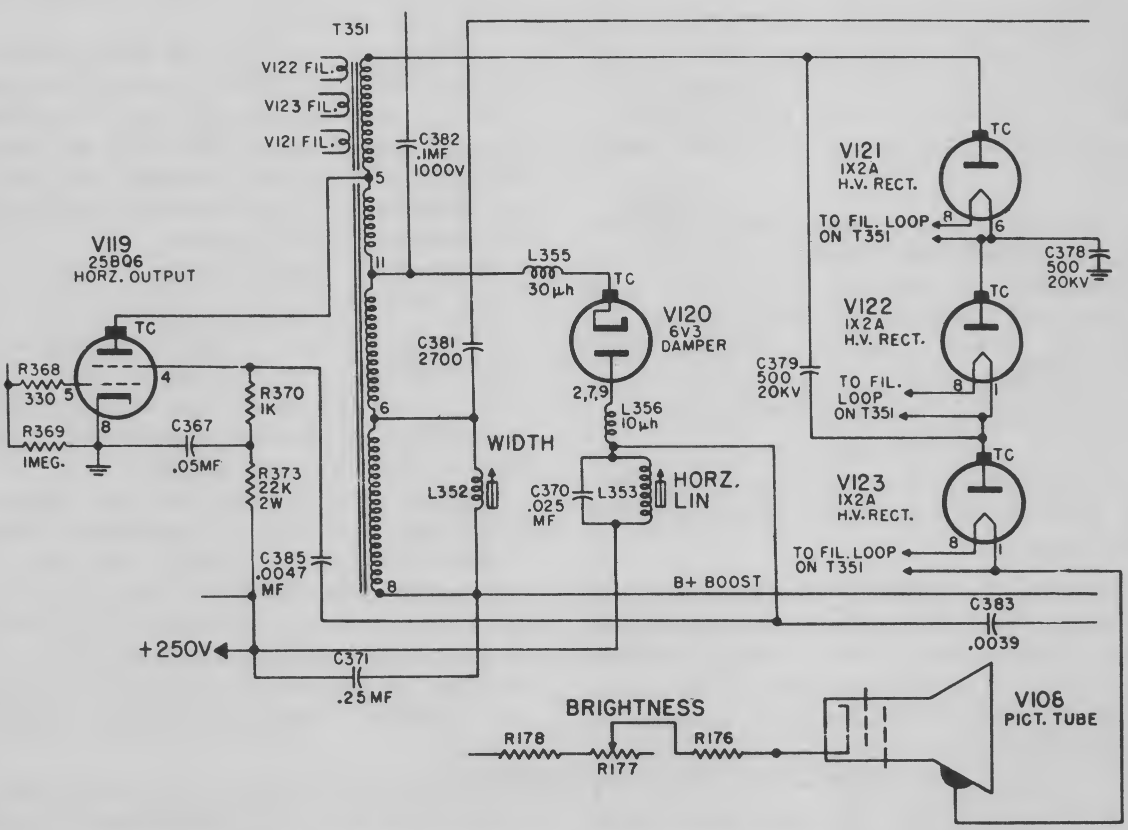


Fig. 4-2. High-voltage supply: GE Stratopower receiver.

2. Dim Picture, due to reduced high voltage or to blooming accompanied by poor focus.

3. Arcing, which can be heard either in the speaker or directly from the source of arc. Arcing may cause the picture to jump or may cause horizontal tearing.

4. Corona, which may not have an immediate effect on the picture. It is recognizable by a bluish discharge at the source and by the presence of an ozone smell. Corona may cause gradual deterioration of the components.

C. Troubleshooting Techniques

1. The General Procedure is the same as outlined previously. Adjustment of controls involves the drive and frequency controls. The drive control should be advanced to see if greater drive voltage helps. The frequency controls may be varied if this circuit falls under suspicion. However, the position of the controls should be noted, so that they may be returned to their original setting if readjusting them does not clear up the trouble.

2. Isolating the Defect to the High-Voltage Circuit. Loss of brightness on the screen may be caused by many factors. The high-voltage circuit should be investigated only after determining that high voltage does not exist at the accelerating anode of the CRT.

a. Checking High Voltage with VTVM or VOM High-Voltage Probe. This may be determined quickly by the use of a high-voltage probe in conjunction with a VTVM or VOM. This voltage should, if possible, be checked with the anode lead connected to the CRT. Thus, it will be checked under load.

Note: Interpreting High-Voltage Reading. If the voltage is proper under load at this point, then the trouble is elsewhere and the high-voltage section need not be investigated. If the voltage is improper at this point, it is next checked without a load. If this check indicates a marked voltage increase without a load, then several components should be investigated: first, the CRT and its associated brightness circuit; next, the high-voltage rectifier (s) and the high-voltage limiting and filament-limiting resistors associated with the rectifier tube.

b. Checking by High-Voltage Arcs. It is possible to obtain voltage indications at the anode lead without the use of a probe. This is accomplished by placing the anode lead close to ground and noting the distance at which a discharge starts to form. It is usually not necessary to permit a complete arc to develop. If possible, the complete arc should be avoided or maintained only for a minimum length of time. This arc causes components to be overloaded, and failure of the limiting resistor or rectifier tube may result.

c. D-C and A-C Arcs. The type of arc may also indicate the amount of ac present at the anode lead. Thus, a sharp spat (d-c arc) would indicate proper output from a filtered rectifier, while a shorted rectifier might produce a quieter, twisting a-c arc.

d. Absence of High Voltage at Anode Lead. Complete absence of voltage at the anode lead definitely indicates high-voltage trouble. This may be due to the high-voltage circuit itself, which includes the rectifier (s), filter capacitor (s), limiting or voltage-doubling resistors, and bad contacts or shorted or carbonized components. A high-voltage capacitor (Fig. 3-15, C525) may break down only under high voltage. A simple resistance check would not reveal this. It is therefore necessary to check circuit operation with one end of the capacitor open-circuited to determine whether a shorted or leaky capacitor is causing reduction or loss of high voltage. Another important cause for loss of high voltage is the absence of the proper pulse on the plate of the rectifier tube.

e. Checking for the High-Voltage Pulse. The pulse on the rectifier plate cap may be checked by the use of the a-c high-voltage probe mentioned previously. The exact pulse shape and size obtained with this probe depends on the equipment used and the set tested. Since this information is rarely included in the receiver data, it must be checked on a good receiver for comparison.

It is not only possible, but also accepted practice, to check this pulse with an insulated screwdriver. In this test the metallic part of the screwdriver is brought close to the rectifier plate cap, and a corona discharge will be created between the plate cap and the screwdriver. Experience will indicate the size of the discharge to be expected.

When using either method to check for the a-c pulse, allowances must be made for the fact that a voltage-doubler circuit requires a smaller input pulse. If the check shows insufficient pulse voltage, the plate cap should be disconnected from the rectifier circuit to eliminate the possibility of a shorted rectifier circuit before proceeding.

When it is certain that the pulse supplied to the high-voltage section is at fault, the previous sections should be explored. If a pulse exists on the plate of the output tube, then the high-voltage winding of the horizontal output transformer should be checked. If there is no pulse at this point, then the troubleshooting procedure outlined under "Troubleshooting the Horizontal Deflection Circuit" should be followed.

3. Voltage Doubler Circuit Servicing. All the steps outlined for troubleshooting the high-voltage circuit pertain to the voltage-doubler circuit. All

references to the plate cap of the rectifier mean the input rectifier in particular (Fig. 4-1, V303; Fig. 4-2, V121). It is possible further to isolate trouble in a voltage-doubler circuit by checking the doubler resistor (s) (Fig. 4-1, R318 to R321) or by checking the voltage on C319. For troubleshooting purposes it is also possible to eliminate temporarily one of the rectifier tubes from the circuit. The input tube may be eliminated from the circuit, and the lead from the transformer originally connected to the plate of the input tube is connected to the output tube plate, with all other phase connections removed. Or the output tube can be eliminated by disconnecting C317 in Fig. 4-1, or C379 in Fig. 4-2. In either case the voltage checked at the output filament of the rectifier of the circuit under test should be approximately half the total output voltage requirements.

4. Arcing in the High-Voltage Cage. Analysis of a high-voltage arc will help determine its cause, and thus the cure. An arc develops because the potential difference between two points is greater than the insulating medium can withstand. Since free electrons tend to accumulate on a sharp point, any sharp-pointed conductor will increase the possibility of arcing.

An arc may occur across a resistor that is carrying current in a high-voltage circuit, if the resistance increases in value. This is due to the voltage increase across the resistor. Similarly, an arc occurs if a short develops at the low end of a high-voltage resistor. Therefore, a pointed solder connection, a shorted high-voltage capacitor, a limiting resistor which has increased in value, or a ground too close to a high-voltage point may all cause arcing.

5. Arcing in Picture and/or Sound. If arcing is heard and it is suspected that the high-voltage supply is at fault, the high-voltage section is disabled. If this eliminates the indications of arcing, then the components of the high-voltage section are checked to determine the defect.

Arcing in the picture is more difficult to localize. In the shop another test receiver with an indoor antenna is placed close to the suspected high-voltage section. The effects of the arcing should be visible on the test receiver. The high-voltage section of the suspected receiver is then disabled. If the indications of arcing are eliminated, then components of the suspected high-voltage section are checked to determine the defect.

6. Resistance of Primary Winding of Horizontal Output Transformer (Autotransformer). The resistance values in the autotransformer primary winding of the horizontal output transformer will vary among the various receivers. Therefore, it is not possible to give specific values as a yardstick. However, in the new receivers checked, the following ranges of values were found.

Output plate cap to rectifier plate cap: 65 to 800 ohms; point 5 to plate cap of V121 (see Fig. 4-2).

Output plate winding: 18 to 75 ohms; points 5 to 8 (see Fig. 4-2).

CHAPTER 5. SYNC SECTION SERVICING

I. SYNC SECTION OPERATION

A. Function

The sync section separates the vertical and horizontal sync pulses from the composite video signal, and then amplifies them and feeds them, or their equivalent, to the respective deflection oscillators. The sync pulses cause the deflection oscillators to fire at the proper frequency and phase, so that the CRT is scanned at the same rate as the camera tube at the transmitter and in the same relative position.

B. Basic Sync System

The composite video signal consists of the video signal and blanking pulses on which are superimposed the sync pulses. The composite video signal is taken from the video detector or video amplifier and is coupled to the sync amplifier and separator stages. In these stages the video information and blanking pulses are removed and the sync pulses amplified. Filter networks separate the vertical and horizontal pulses from each other. This is known as *inter-sync separation*. These filter networks also couple the sync pulses to the vertical oscillator and horizontal afc system, respectively.

C. Typical Sync Separation Circuits

The sync amplifier and separation circuits are usually common to the vertical and horizontal stages. Some manufacturers use individual vertical and horizontal separation circuits, but this is not a frequent practice. The recent trend is to include noise limiters and fringe-compensating circuits in the separator stages.

A large variety of sync separation circuits is in use today. However, the differences are minor. Sync separation stages accomplish the same thing; namely, the elimination of video information and blanking pulses, leaving only the sync pulses.

Some typical sync separation stages in use in current receiver models will be described in the following paragraphs.

1. Motorola Model 21T 4AC. Figure 5-1 is the schematic diagram of the sync amplifier and separator circuits used in a late Motorola chassis.

A positive-going video signal is applied to the grid of V12A through C62 and the filter network consisting of R52, C64, and C63. The PP amplitude of the video signal at the grid is 30v. By grid-leak action, capacitor C62 charges up to the peak amplitude and a 30-v bias is developed. The tube is cut off, except during the tips of sync pulses. Some video information and noise pulse in the "black" region may also cause conduction. V12A is the first clipper, or limiter.

A negative-going sync pulse, 26v PP, appears in the plate of V12A. There is a small amount of video signal remaining. This is eliminated by grid clipping in V12B. V12B also functions as a phase inverter. There are three outputs from V12B.

a. From plate, pin No. 5, a positive-going sync pulse is fed to the integrating network to trigger the vertical oscillator. This network consists of C67, R59, C68, R60, and C69 and is a low-pass filter which eliminates the horizontal sync pulses but leaves the vertical. It is identified by the fact that it is usually a two-section pi filter, and the output is taken across a capacitor.

b. From the cathode, pin No. 6, a negative-going sync pulse is coupled to the horizontal phase detector.

c. From the plate, across R58, a positive-going sync pulse is also coupled to the phase detector. Operation of this circuit will be discussed later.

Servicing the circuits just described is simplified by these considerations:

(1) Loss of both vertical and horizontal sync is reflected in troubles in the common stages. These include the sync take-off in the plate of the video amplifier, the circuits of V12A, and of V12B up to (but not including) C67, C66, and C76.

In the event of loss of both vertical and horizontal sync, the technician probes these circuits with an oscilloscope. Checks are made of both the amplitude and shape of the waveform and they are compared with those specified by the manufacturer (see Fig. 5-1). A more detailed discussion of troubleshooting these circuits will be given later.

(2) Loss of vertical sync alone is due to defects in C67, any of the components of the integrating network, or in the vertical oscillator circuit.

(3) Loss of horizontal sync alone may be due to defects in C66, C76, or the horizontal afc circuit.

2. Sync Noise Inverter. The recent trend in sync amplifiers is for the inclusion of noise inverters or cancellers to eliminate the effects of noise on the sweep oscillators.

Figure 5-2 shows the noise inverter circuit used in recent GE receivers. A negative-going composite video signal is coupled from the video detector through C314 to the control grid of V113A, the sync amplifier. The noise inverter, V113B, is in parallel with the load of V113A. When V113B conducts, it effectively shorts out the output of V113A. It will

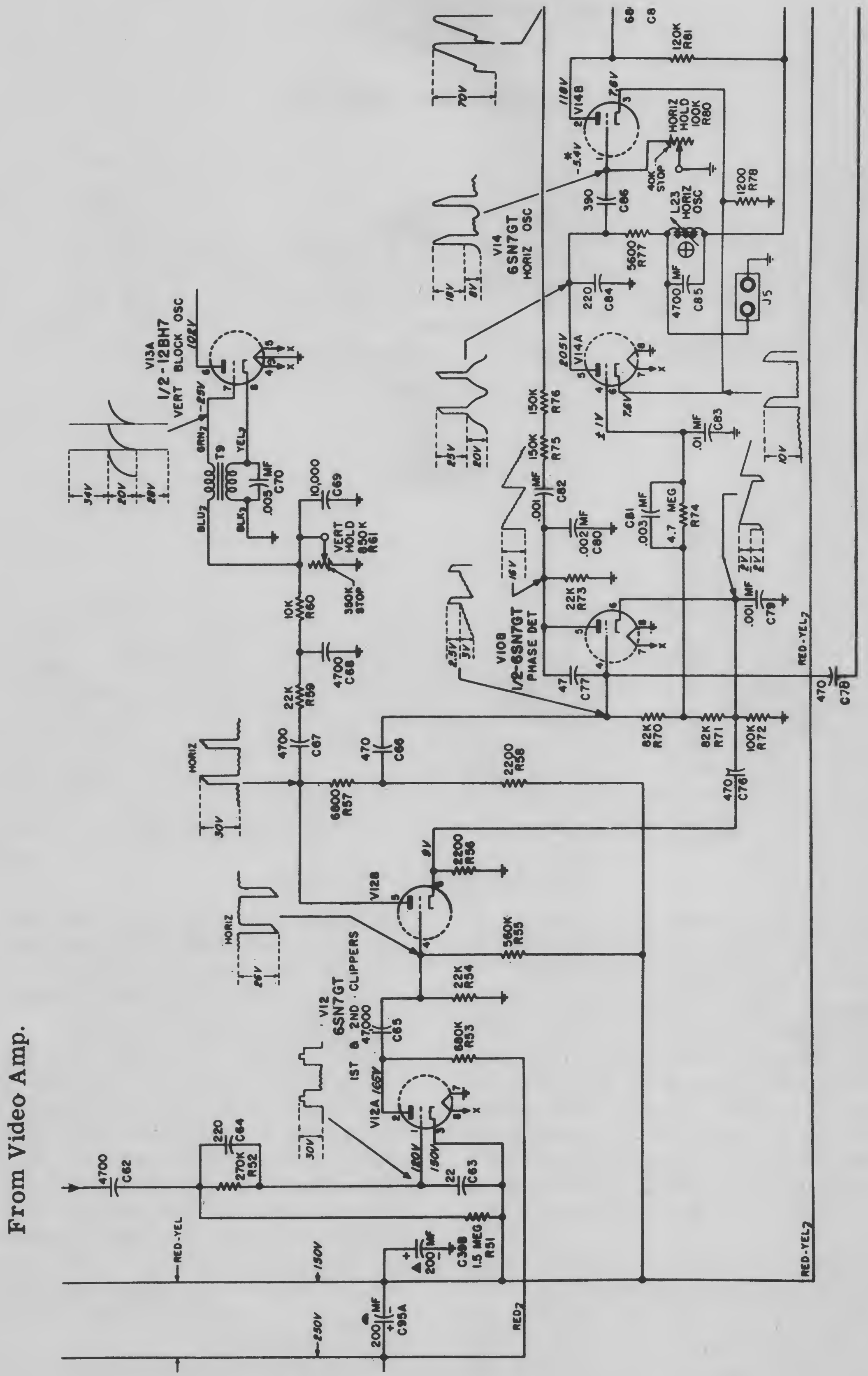


Fig. 5-1. Sync circuits: Motorola Model 21T4AC.

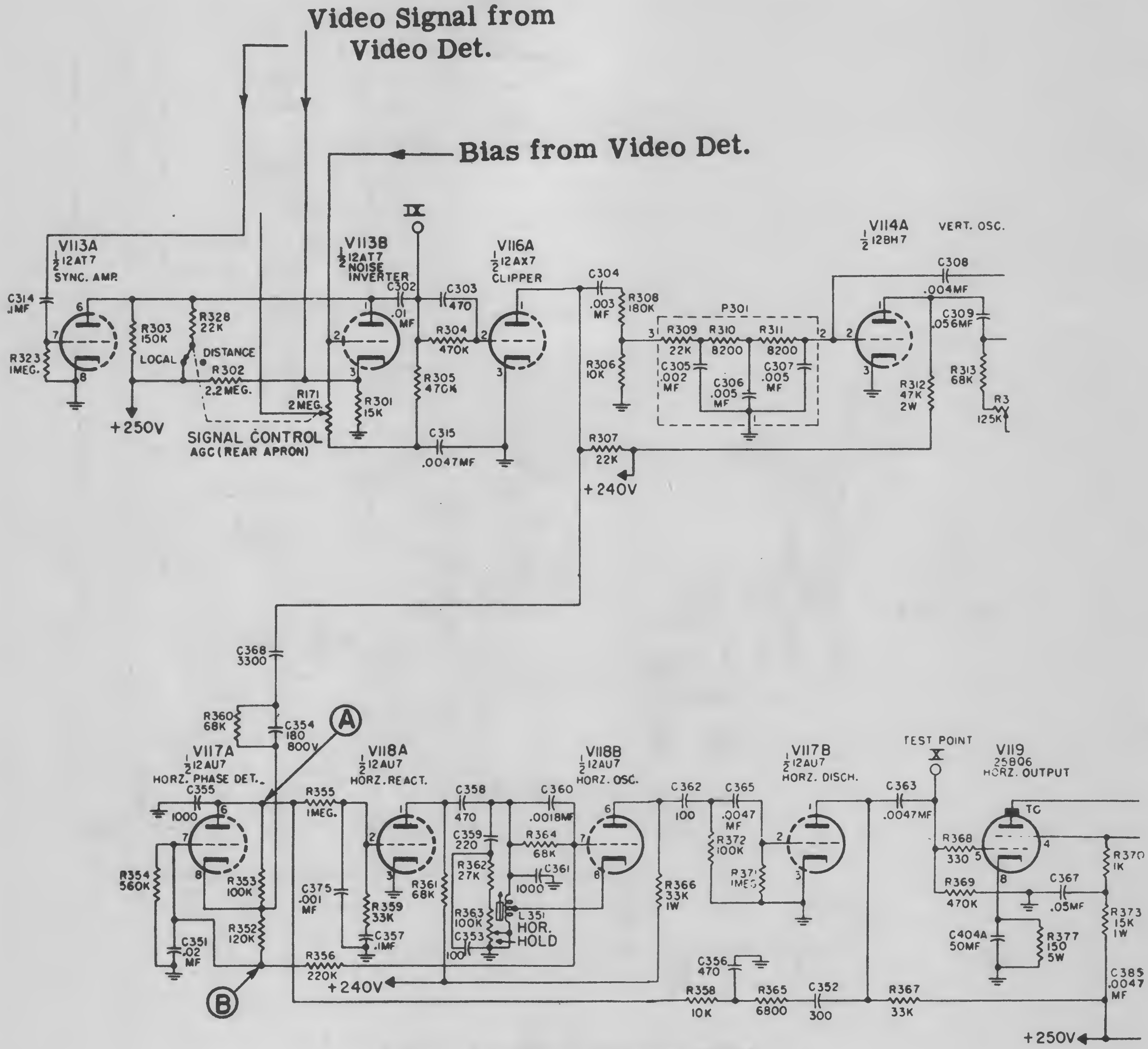


Fig. 5-2. Sync circuits: GE Model 17C125.

be shown that this occurs when noise pulses of the same polarity as, but larger in amplitude than, the sync pulses appear in the composite video signal.

The cathode of V113B is kept positive by the voltage divider network consisting of R301 and R302. The grid of V113B is biased negatively by the rectified and filtered video signal from the crystal, the video detector. The negative voltage on the grid of V113B depends on the amplitude of the sync pulses from the video detector. The combination of cathode and grid voltage maintains V113B below cut-off, so that it will not conduct in the presence of a normal video signal.

A negative-going video signal is capacitively coupled from the video detector to the cathode of V113B. As was previously explained, the tube normally will not conduct. However, when a signal with a large negative noise pulse appears on the cathode, the tube will conduct heavily during the noise interval and will short out the sync amplifier. Thus, during the time of the noise pulse, both sync pulses and noise pulses are shorted out and neither will be present in the output of the sync clipper, V116A. During this interval, the fly-wheel effect of the sweep oscillator will maintain proper frequency.

Under normal conditions, the sync amplifier, V113A, amplifies and inverts the video signal applied to its control grid. The positive-going video signal in the plate is coupled by C302 and C303 to the control grid of V116A, the sync clipper. Grid-leak action biases this tube to cut-off. The bias is maintained by the long time constant, C302 and R305, between sync pulses. The tube conducts only during the most positive portion of the incoming signal; that is, the tips of the sync pulses. Hence, only the sync pulses are passed by V116A and sync separation has thus taken place.

The Local-Distant switch operates to increase the gain of the sync amplifier, V113A, in a fringe area where signal strength is low. In the "Local" position

the plate load in V113A consists of the parallel combination of R303 and R328. In the "Distant" position only R303 is in the circuit. The larger plate load thus increases the gain of the stage for weak signals.

The output from the plate of the clipper consists of negative-going vertical and horizontal sync pulses. These take two paths:

a. Through C304 and the divider network consisting of R308 and R306 to the integrating network (a printed circuit shown in the diagram as P301). The integrating network passes the vertical sync pulses to trigger the vertical oscillator, V114A.

b. Through C368 and the parallel filter of R360 and C354 to the horizontal phase detector.

In troubleshooting these circuits the technician will look for troubles affecting both vertical and horizontal sync in the common stages: V113A, V113B, and V116A.

Loss of vertical sync alone will be sought in the integrator and vertical oscillator.

Loss of horizontal sync alone will be sought in the horizontal afc circuits and the horizontal oscillator.

3. Pentagrid Sync Separator and Noise Clipper. Recently, there has been a marked trend toward the use of a pentagrid tube to accomplish sync separation and noise clipping. Figure 5-3 is the schematic diagram of the Zenith sync clipper and fringe lock circuit used in the K chassis.

There are two inputs to this tube. The first is a negative-going composite video signal applied to grid, pin No. 1. The second is a positive-going video signal, about 40v PP, applied to grid, pin No. 7.

Let us first consider the second signal. It will be noted that the 6BE6 acts as a limiter for this signal. The plate (pin No. 5) is, by voltage divider action of R6 and R51, at low positive potential, 30v. The screen voltage is 20v. The 40-v PP positive-going signal, applied to grid (pin No. 7), causes this grid to draw current, charging C31 to about 40v. This voltage is maintained between sync pulses by the long time constant, C31 and R55. Accordingly, the tube is biased beyond cut-off and only the tips of the sync pulses cause plate current to flow, thus accomplishing sync separation.

The first signal, applied to grid (pin No. 1), acts to reduce the effects of noise in the sync circuits. R54, the fringe lock control, permits biasing this section of the 6BE6 at the optimum value, depending on noise conditions. The bias is adjusted so that the negative sync tips do not cut off plate current in the 6BE6. Any noise voltage (negative-going and larger than the sync pulses) applied to grid (pin No. 1) will cut off plate current, and the noise pulses will therefore not appear in the plate of the 6BE6. Neither will the sync pulses appear during this time. However, the oscillators will be kept in sync momentarily by their fly-wheel effect. There will be no noticeable effect on the picture unless the noise burst is of long duration.

The fringe lock circuit is effective in areas of weak signal, where there is noise present. It is particularly

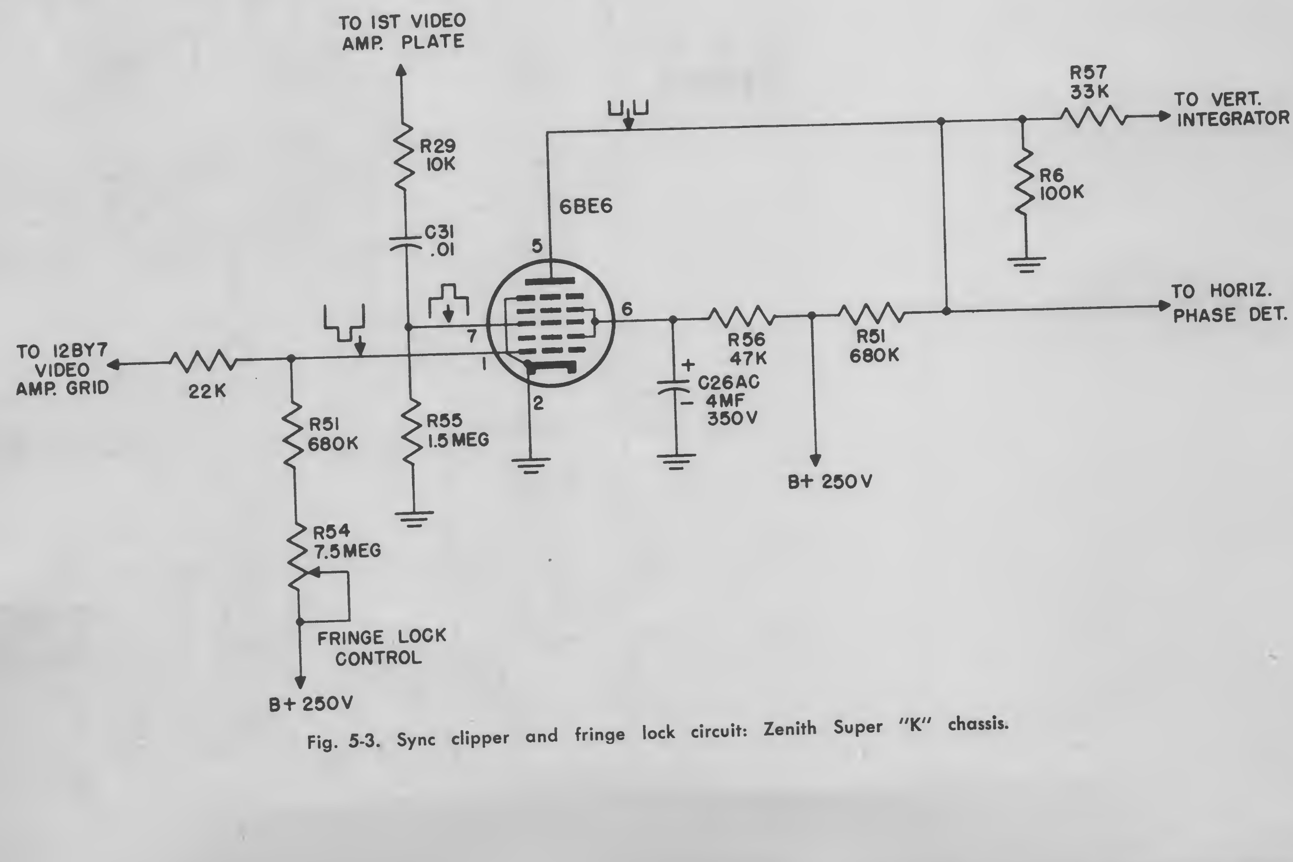


Fig. 5-3. Sync clipper and fringe lock circuit: Zenith Super "K" chassis.

effective in stabilizing the vertical oscillator and is set for maximum vertical oscillator stability.

The negative-going sync pulses appearing at the plate, pin No. 5 of the 6BE6, are then applied to the vertical integrator and the horizontal phase detector.

Trouble affecting both vertical and horizontal sync should be sought in this common sync separator and noise clipper stage.

4. Separate Vertical-Horizontal Sync Clippers. The sync circuits of the DuMont RA162, unlike those previously studied, contain separate vertical and horizontal sync clippers. Figure 5-4 is a schematic diagram of this circuit. The common sync take-off is the plate of the video amplifier. The positive-going composite video signal at this point feeds two paths.

a. Vertical Sync Separation. The input to the first vertical clipper acts to integrate the vertical sync pulses. This is accomplished by the action of R269 and the input capacity of V212B. This network also attenuates the horizontal sync pulses and video information.

The cathode of the vertical clipper derives its bias from the cathode of the sync amplifier, V212A. This maintains V212B close to cut-off, so that only the integrated vertical pulse and some of the video information gets through V212B and is coupled to the control grid of V213, the second vertical clipper. The second vertical clipper is biased in its saturation region, and hence limits the incoming vertical sync signal and any extraneous video pulses which may still remain.

The positive feedback network, consisting of R271, C268, and R268, applies part of the positive sync signal at the plate of the second clipper back to the grid of the first vertical clipper. This results in increasing the gain of the vertical sync stages on weak signals and improves vertical sync stability.

C267 bypasses the video signal appearing in the input circuit of V212B and thus prevents it from feeding into the vertical sync output at the plate, pin No. 1 of V213.

The sync pulse is taken from R298 and fed to the vertical oscillator through the integrating network.

b. Horizontal Sync Separation. The composite video signal is also fed to the control grid, pin No. 2 of V212A, the horizontal sync amplifier. This tube is biased close to cut-off by cathode bias. Only the horizontal sync pulses are passed by the tube. The cathode capacitor, C260, does not act as a good bypass

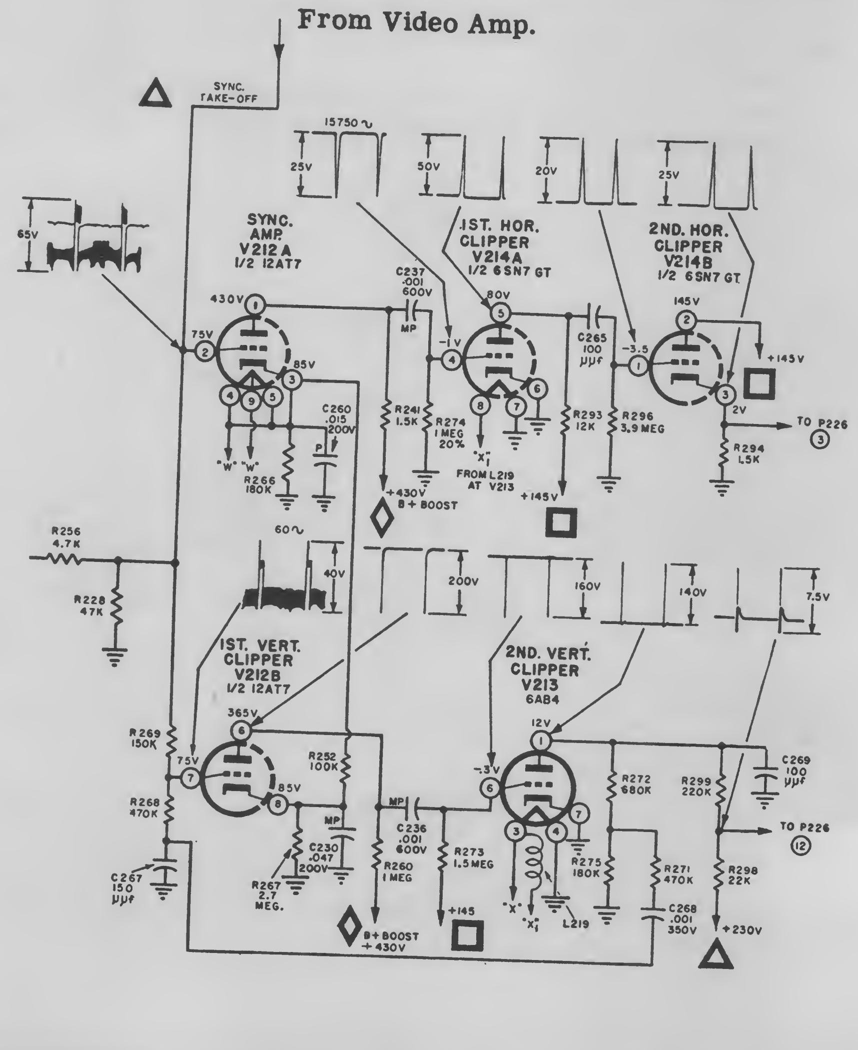


Fig. 5-4. Sync circuits: DuMont RA162.

for the low-frequency vertical pulses, and therefore the vertical sync pulses are attenuated.

The negative-going horizontal sync pulses are applied to the grid of the first horizontal clipper, whose function is to eliminate any extraneous signal by clipping the top portion of the sync pulse. The polarity of the horizontal sync pulses in the grid of V214B is positive-going. This tube is grid-leak biased and acts further to limit the sync pulses. It is also a cathode follower and applies the horizontal sync pulses from R294 to the horizontal afc system.

From a servicing viewpoint, troubles common to both the vertical and horizontal sync systems may be sought in V212A and V212B, or in the circuits prior to the common sync take-off.

Vertical sync troubles may be found in V213 and in the vertical oscillator and its input.

Horizontal sync troubles may be found in V214A and V214B, the horizontal afc system, and the horizontal oscillator.

5. Identification of Sync Separation Stages. The sync separator stages are most easily identified by the input and output signals. A composite video signal is fed to the input. This may be negative- or positive-going, depending on the take-off. The output from the sync stages consists of sync pulses only. The video information has been removed.

The sync separator stages use clippers and limiters that operate on the signal at cut-off and saturation, and are usually common to both vertical and horizontal sweeps. Therefore, the output feeds the vertical oscillator (through an integrating network) and the horizontal afc control system.

II. VERTICAL SYNCHRONIZATION

A. Requirements of Oscillator Circuits

The output of the integrating network is used to trigger the vertical sweep oscillator. This is a positive- or negative-going waveform, shaped by the charging of the integrator capacitors. The polarity of the sync pulse for the basic oscillator circuits is as follows:

1. Blocking Oscillator. This requires a positive-going sync pulse applied to the control grid.

2. Cathode-Coupled Multivibrator

a. This requires a negative-going pulse if applied to the input grid of the normally "On" tube; and

b. A positive-going pulse if applied to the common cathode. In both cases the amplification of the tube is used to increase the gain of the sync pulse, so that it will be sufficiently large to be effective in locking the frequency of the oscillator.

It is apparent that noise pulses, if of sufficient amplitude and proper polarity, may also trigger the vertical oscillator. However, the frequency of sporadic noise pulses is usually high compared with the 60-cps vertical sync pulses. Hence, noise pulses in the vertical circuit are attenuated or eliminated by the integrating network, whose long time constant increases its noise immunity. However, the noise limiters discussed previously are now used to gain *additional* noise immunity.

3. Plate-Coupled Multivibrator

a. This requires a negative-going sync pulse if applied to the control grid of the normally "On" tube.

b. This requires a large positive-going sync pulse if applied to the control grid of the normally "Off" tube.

B. Troubleshooting the Vertical Sync Circuits

From the discussion of sync separation it is apparent that sync separation stages, in most receivers, are common to both the vertical and horizontal sync systems. Usually, troubles that develop in these common stages will result in the loss of vertical and horizontal sync. However, trouble in common stages may sometimes affect the vertical oscillator and not the horizontal oscillator because of afc action in the horizontal sync system.

If there is loss of vertical sync only, the trouble should first be sought in the vertical sync stages not common to the horizontal circuits. Thus, in the case of the GE, Motorola, and Zenith circuits discussed, vertical troubles would be sought in the integrating networks.

1. Indications of Vertical Sync Defects. Some of the common defects and their possible causes are listed here.

a. Poor, or Complete Loss of, Vertical Sync. This condition is characterized by up or down rolling of the picture. The speed of rolling will depend on the extent of frequency deviation from 60 cps. It may be caused by: improper setting of the vertical hold control; defective tube or component in the vertical oscillator (which may be indicated as vertical sweep trouble such as improper height); defective component or tube in vertical sync separator stages (if not common to horizontal sync) or in the integrating network; defective agc system (although this is more likely to affect the horizontal sync section); and improper setting of the agc level control.

b. Vertical Jitter. This is due to improper setting of the vertical hold control or from random

noises triggering the vertical oscillator.

c. Loss of Interlace: Paired Lines. On a test pattern the horizontal wedges will show loss of interlace or moire effect. This condition is due to horizontal pulses or video information accompanying the vertical sync pulse at the grid of the vertical oscillator. Trouble may also result from defective components in the integrating network; inadequate sync separation due to improper operation of sync clippers; leaky common bypass capacitors in the circuits from the video amplifier to the vertical oscillator.

d. Vertical Blanking Bar. A hum at 60 cps may cause the sync to be improperly phased and show a vertical blanking bar.

2. Procedure for Troubleshooting Vertical Sync Circuits. The basic troubleshooting procedure is the same as outlined previously. The controls that will affect vertical synchronization are: the vertical hold and height, and also linearity (in plate-coupled multivibrator); and the vertical lock-in range, if present.

a. Isolating Defective Stage with an Oscilloscope or a Low-Capacitance Probe. Troubleshooting the vertical sync circuits is usually done with an oscilloscope, but it is preferable to use a low-capacitance probe. If a direct probe is used, the probe should be shielded. However, circuit loading may occur with a direct probe.

The scope is used in a signal-tracing process in the same manner previously outlined for the sweep circuits. The signal is inspected for waveform and amplitude in those vertical sync stages not common to the horizontal sync path. The waveform is then compared with the published waveforms at the check points chosen. Trouble is indicated at the point where the signal departs from normal. Amplitude deviations up to 20 percent PP may be accepted as normal.

In tracing the waveform in the integrator network, up to the input grid of the vertical oscillator, the vertical oscillator should be removed from the circuit when possible. If a series-parallel filament arrangement or some circuit peculiarity makes this inadvisable, the oscillator should be killed by replacing with a dummy tube having the same filament characteristics. If this is not available, oscillator action may be stopped by eliminating the feedback path. For example, in a cathode-coupled multivibrator short out the common cathode; in a blocking oscillator short either primary or secondary of the vertical blocking transformer. The purpose is to keep the oscillator kickback from coupling into the sync circuits and obscuring the sync pulse.

b. Isolating Defective Stage with VTVM or VOM. When a defective stage has been localized with an oscilloscope, it may be necessary to make a voltage and resistance analysis to determine the defective component. With respect to these tests, the same observations apply here as in the sweep circuits. Variations greater than 20 percent from the published data indicate trouble. An analysis of the voltage and/or resistance readings will lead to the defective part which must be replaced.

III. HORIZONTAL SYNCHRONIZATION — AFC SYSTEMS

A. Need for AFC in Horizontal Sweep Oscillators

The early postwar TV receivers did not use afc to control the frequency of the horizontal oscillator. As a result, the horizontal circuits were unstable, frequently lost synchronization, and were a constant source of annoyance.

The horizontal sync filter utilizing a simple differentiating network was inadequate because the circuits were not immune to noise. The vertical sync circuits, which incorporated the integrator (a low-pass filter), were much more immune to noise. As a result, afc for the horizontal oscillator was introduced.

Basically, afc circuits are alike. The circuits compare the frequency of the horizontal sync pulses with the frequency of the horizontal oscillator. If there is any frequency or phase difference, a d-c correction voltage is generated which is applied to the oscillator to bring it back to frequency. The d-c voltage is filtered by a low-pass filter to eliminate the effects of noise impulses.

B. Types of AFC Circuits

There are two basic types of afc circuits in use today; namely, the phase detector and the pulse width. However, variations are present within each type.

1. *The phase detector* variations are identifiable as follows:

a. A duo-diode as a phase discriminator, a reactance tube, and a Hartley-type oscillator in the RCA 630-type receiver.

b. A triode phase detector, a reactance tube, and a Hartley-type oscillator in the GE Stratopower chassis.

c. A triode phase detector with a cathode-coupled multivibrator in the Capehart Model CX37, Emerson Model 727D, Admiral 22F2 chassis, and the Philco R201 chassis.

d. A duo-diode phase detector with a cathode-coupled multivibrator in the CBS-Columbia 1027 chassis; the Hoffman 195 chassis; the Hallicrafter

AR1200D; the Wells-Gardner Model GS40; the Stromberg-Carlson 521 Series; and the Belmont Raytheon Model 17T1.

2. *The pulse width* system variations are:

a. Gated tube, using three pulses for comparison and operating on a blocking oscillator.

b. Gated tube, using two pulses for comparison and operating on a blocking oscillator. This circuit is used in the DuMont RA162 (see Fig. 5-4), RCA 17T301, and the Admiral 19K1 chassis.

Each of these two systems will be discussed in detail in paragraphs C and D which follow in this section.

C. Phase Detector Systems

1. Synchrolock. This is the trade name for the system used in the original RCA 630 receiver and still found in the 630-type receivers manufactured today. Figure 5-5 is a schematic diagram of this system.

a. System Operation. V125 is a Hartley oscillator, whose frequency range is varied by a slug in the primary of T108. The plate circuit of the control tube, V124, is in parallel with the primary of T108 and constitutes part of the reactance (inductance) across it. An increase or decrease of current through V124 is felt as a decrease or increase, respectively, in inductance across the primary of T108. There is a respective raising or lowering of frequency of V125.

The current flowing in the control tube is governed by the control grid voltage, normally –2v. Variations in this voltage constitute the d-c control voltage which stems from V123, the horizontal sync discriminator. This 6AL5 compares the positive sync pulses, which appear in the same polarity on its plates, with the oscillator sine wave induced in the

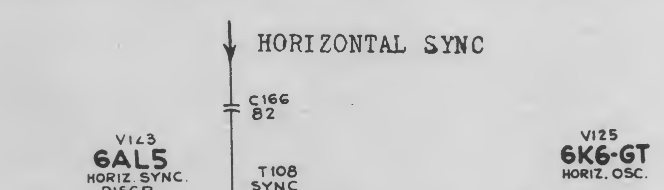


Fig. 5-5. Horizontal control circuits: RCA 630.

secondary of T108. This sine wave, by transformer action, appears in opposite phase on the plates of the 6AL5.

The circuit constants have been arranged so that the discriminator output is zero when the frequencies of the sync pulses are the same as the frequency of the oscillator. If the oscillator drifts above or below 15,750 cps, the discriminator output is more negative or less negative than the fixed –2v. A more negative voltage, fed to the grid of the reactance tube, V124, decreases plate current, increases the effective inductance of V124, and as a result, lowers the frequency of V125; and vice versa. Thus, control of the oscillator is effectively maintained by the action of the circuit.

The d-c output of the 6AL5 is filtered by the action of C167 and R193. This parallel combination is a low-pass filter, and it eliminates noise voltages which may have entered the circuit with the sync pulse.

b. Troubles in Synchrolock System. The characteristics of each of the three tubes in this system are critical for proper operation. Thus, changes in the characteristics of the 6AC7 will affect the frequency of the oscillator. As this tube ages, changes will occur. Readjustment of the primary of T108, the frequency control on the rear apron of the chassis, may compensate for oscillator drift resulting from these changes. If it does not, it will be necessary to replace 6AC7.

Similarly, the 6AL5 is used in a balanced circuit. If either of the two tubes in this envelope changes characteristics, the d-c control voltage output will be affected, thus upsetting circuit operation.

The 6K6 characteristics determine proper operation of the sine-wave oscillator. A change in characteristics may also affect frequency or even the ability of the tube to oscillate.

If trouble is suspected in these tubes, a logical procedure, obviously, is to replace them with known good tubes.

Another source of trouble results from improper adjustment of transformer, T108. Misadjustment of the secondary may cause horizontal foldover or picture shift. Improper adjustment of the primary will cause complete loss of horizontal sync.

2. Triode Phase Detector — Reactance Tube and Hartley-Type Oscillator. GE Model 21T1 uses this circuit (Fig. 5-2). Here, as in the preceding circuit described, the control system compares the frequency and phase of the horizontal sync pulses with the output of the horizontal sweep circuit. However, here V117A, a triode, is used in a transformerless circuit.

a. System Operation. Any frequency or phase difference is converted into a d-c correction voltage which is applied to V118A, the reactance tube. This

tube, in turn, brings the Hartley oscillator, V118B, back to its proper frequency.

The input to V117A consists of negative-going horizontal sync pulses, coupled to the cathode through C354 and R360, and a horizontal positive-going sawtooth wave from the horizontal discharge tube applied to the plate.

This triode acts like two diodes in operation. The cathode-to-grid circuit constitutes one diode; the cathode-to-plate circuit, the other diode. The current characteristics of these two diodes is identical for the small sync voltage applied. Hence, the voltage across the two load resistors, R352 and R353, is the same. Therefore, point *A* (plate, pin No. 6 of V117A) is at zero potential with respect to point *B* (grid, pin No. 7 of V117A). Components R354 and C351 are outside the load circuits and do not affect our discussion of sync action.

The sawtooth voltage is applied from the horizontal discharge tube through C352, R365, and R358. The phase of this sawtooth with relation to the sync pulse determines the d-c output from V117A. If the horizontal oscillator frequency is correct, the sync pulse will appear at the center of the retrace. Therefore, grid and plate currents will be equal and no d-c voltage will be applied to the reactance tube. Figure 5-6 shows this first condition, together with the two other possibilities. This graph represents conditions at the cathode with respect to the plate in the cathode-plate diode section. The positive sawtooth which appears at the plate is effectively the same as the negative pulse shown in Fig. 5-6.

The second condition shows the sawtooth frequency lower than 15,750 cps. The sync pulse appears below the zero level and the plate circuit draws more current than the grid circuit. As a result, the d-c control voltage at point *A* is negative with respect to ground. It may be seen that this will reduce the effective capacitance across the horizontal oscillator tank circuit and increase its frequency, returning the oscillator to 15,750 cps.

Similarly, the third condition shows the horizontal sawtooth frequency higher than 15,750 cps. Plate current flow is less than grid current flow and the control voltage at point *A* is positive, and this will reduce the horizontal oscillator frequency to 15,750 cps. Figure 5-2 shows the reactance tube and its effect on the Hartley oscillator used here.

The d-c output at the plate of V117A is filtered by R355, C375, R359, and C357 and is applied to the grid of V118A, which draws more or less current, depending on the amplitude of the voltage on its grid. V118A in series with C358 is in parallel with the tank circuit of the oscillator, V118B. V118A may be considered a variable resistor in series with C358. When the grid of V118A goes positive, more current

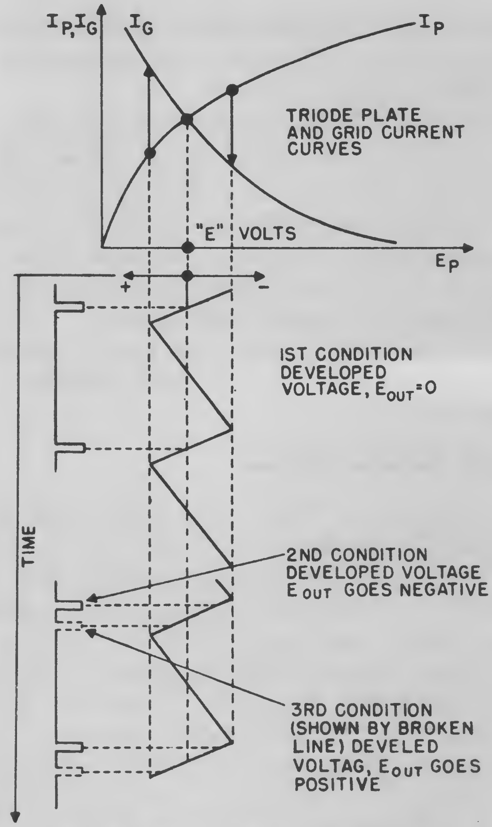


Fig. 5-6. Phase detector operation: GE

flows through it and its resistance decreases. This larger capacitive current makes C358 appear larger to the oscillator tank circuit. Hence, the frequency of the oscillator goes down. We have seen that the control voltage at point *A* goes positive when the horizontal oscillator frequency goes up. Therefore, control of the oscillator is in the proper direction.

Similarly, when the grid of V118A goes negative, due to lower oscillator frequency, current flow through V118A decreases. C358 looks like a smaller capacitor across the tank circuit, and its frequency goes up again to 15,750 cps.

In order to set the operating point of the reactance tube in the middle of its linear plate current characteristic, a fixed bias is applied to the grid. This bias stems from the grid of the horizontal oscillator, coupled through the divider network of R356 and R354. C351 filters this bias to eliminate the a-c component appearing on the grid of the oscillator.

b. Troubles in This AFC System. Loss of horizontal synchronization will occur under any of the conditions listed below:

(1) Defective V117 or V118.

(2) Leaky or shorted C368 or C355.

(3) Open waveform feedback components, C352, R356, and R358.

(4) Shorted C356.

(5) Change in oscillator components, L351, C361, C358, C359, and R362.

(6) Insufficient sync amplitude at input to V117A.

(7) Improper bias and plate voltage on control tube, V118A.

3. Triode Phase Detector Operating with Cathode-Coupled Multivibrator. Typical of this type of control circuit is that used in the Motorola receiver (Fig. 5-1). Here, we again see a triode (V10B) used as a phase detector. However, the horizontal control tube of the previous circuit is eliminated, and instead, the d-c control voltage resulting from the phase detector is fed directly to the input grid, pin No. 4 of a cathode-coupled multivibrator (V14). This type of oscillator can be directly controlled by a d-c voltage.

a. System Operation. Another difference between this and the preceding control circuit discussed is in the sync signal fed to the detector. Here, we see two sync pulses, 180 degrees out of phase from the phase inverter (V12B), fed to the grid and cathode of the detector. A sawtooth horizontal sweep voltage is coupled to the plate and grid of the detector for comparison.

When the frequency and phase of the sync and sawtooth are correct, the negative voltage developed across R71 is equal to the positive voltage developed across the cathode resistor, R72. Therefore, the net voltage output to the grid of V14A (horizontal oscillator) is zero.

When the oscillator frequency increases, however, the phasing is such that it causes plate current to increase more than grid current and the net control voltage then is positive. This effectively slows down the speed of the oscillator, and vice versa. C80, R76, R75, C82, and R73 shape the horizontal output waveform, so that a negative-going sawtooth is applied to the plate of V10B. C81 and R74 filter the d-c output from the phase detector.

b. Troubles in This AFC Circuit. This circuit is stable and will operate fairly well, even under certain abnormal conditions. Thus, an open C66 or an open C76 will make operation more critical, but it will not lose sync after readjustment of the hold control.

Horizontal sync will be lost under the following conditions:

(1) Defective tubes, V10B or V14.
(2) Shorted C83.
(3) Shorted C79.
(4) Change in value of C86 and R80.

4. Duo-Diode Phase Detector Operating with a Cathode-Coupled Multivibrator. There are several variations of this control circuit. However, it may be identified by the fact that the two diodes receive three signals for comparison. Two of these are equal in amplitude, but 180 degrees out of phase. These may be (1) the horizontal sync pulses or (2) the horizontal sweep voltage. The third signal voltage is the horizontal sweep sawtooth under condition (1), or the horizontal sync pulse, under condition (2). Typical of this circuit is the system used in Raytheon 17T11 model (Fig. 5-7).

a. System Operation. The phase detector uses a 6AL5 duo-diode. Horizontal sync pulses from the sync clippers are coupled to the cathodes of the 6AL5 through C79. Two sweep voltages from a sep-

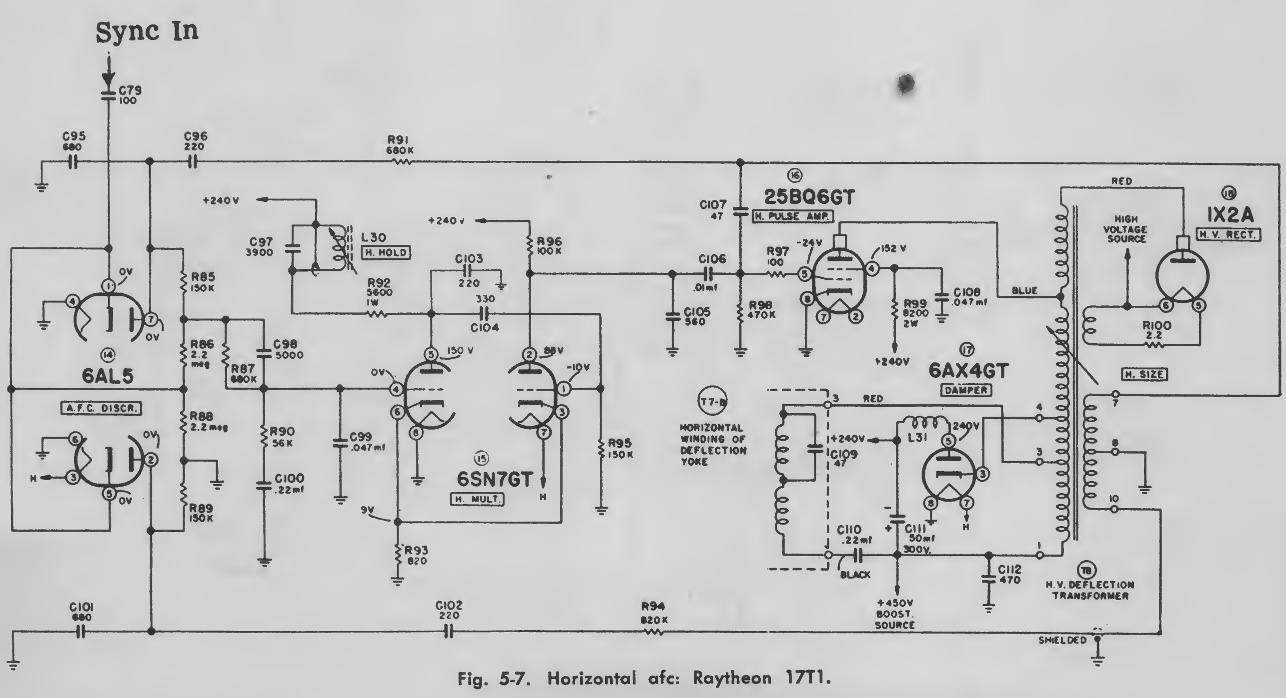


Fig. 5-7. Horizontal afc: Raytheon 17T1.

arate winding of the horizontal output transformer are shaped and fed back as sawtooth voltages, equal but opposite in polarity, to the plates of the afc tubes. Any frequency shift of the horizontal oscillator will cause a phase shift, and one or the other of the diodes will conduct more heavily. This will result in a d-c correction voltage generated across the diode load resistors, R86 and R88. This correction voltage is filtered by C98 and R87 and is applied to the grid of the horizontal oscillator to correct its frequency.

b. Troubles in This AFC System. Loss of horizontal synchronization will result from any of the following causes:

(1) A defective 6AL5 or 6SN7 (horizontal oscillator).

(2) Open C79, C96, C102.

(3) Shorted C95, C101, C99.

(4) Change in value of C104 or R95.

It is interesting to note that a conventional horizontal hold control is not used in this oscillator. The stabilizing coil *core adjustment* serves as the horizontal hold control.

D. Pulse Width System

A recent adaptation of the pulse width system uses just two signals in the control tube. These are the horizontal sync pulse and the sawtooth voltage derived from the horizontal oscillator. In the older pulse width system an additional signal was taken from the horizontal output transformer. In other respects circuitry and operation are the same.

1. Circuit Operation. The system used in the DuMont chassis RA162 is typical. Figure 5-8 shows the horizontal control tube, V301A (one half of a 6SN7) and the oscillator tube, V301B, which uses the other half of the 6SN7. The control tube compares the frequency of the horizontal oscillator with that of the incoming sync pulse. If there is a frequency difference, a d-c correction voltage is developed at the cathode and applied to the grid of the blocking oscillator, increasing or decreasing its frequency as necessary.

The operation of the circuit is as follows. Tube V301A is cut off by a voltage divider to boost B+, R303, and R304. The sawtooth voltage developed across C333 is coupled to the control grid of V301A by C311, the parallel network of C304 and R308, and resistor, R301. A positive-going sync pulse is also coupled from the horizontal sync clipper to the control grid of V301A. The horizontal locking range control, C306A, is adjusted so that the peak of the sawtooth voltage is just below cut-off of the control tube. This gated tube will not conduct if the sync pulse or the sawtooth wave alone appears on its grid. However, the combination of both (Fig. 5-9) will drive it to conduction. The length of time that V301 conducts determines the d-c voltage on the cathode. The grid of the blocking oscillator is returned to this cathode. Thus, the frequency of the oscillator is controlled by the voltage on the cathode of V301A.

Figure 5-10 shows the three conditions of sync and sawtooth voltage. Condition *B* indicates proper phas-

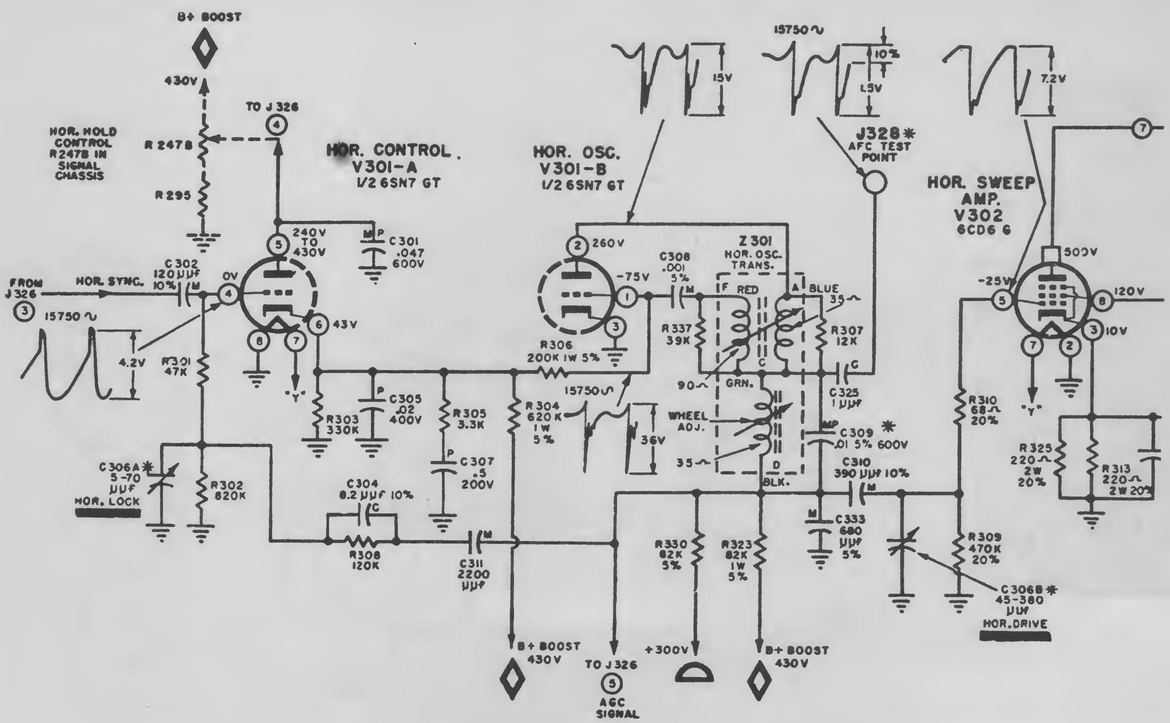


Fig. 5-8. Pulse width afc: DuMont RA162.

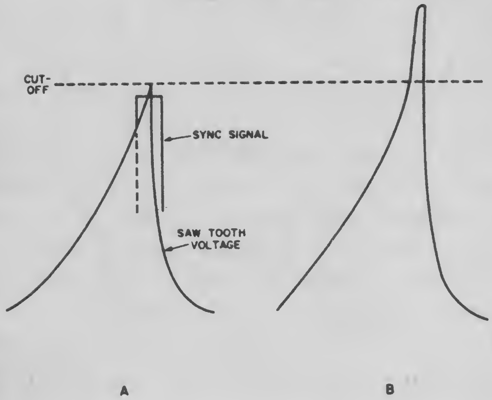


Fig. 5-9. (A) Sync and sawtooth voltages at grid of V301B. (B) Resultant sum of sync and sawtooth voltages. *Courtesy DuMont.*

ing when the two waveforms have the same frequency. Condition *A* is where the oscillator frequency has increased beyond 15,750 cps. The pulse of the combined wave about cut-off is narrower; therefore, there is a lower voltage on cathode of V301A and the oscillator frequency is automatically reduced. Condition *C* is where the oscillator frequency is less than 15,750 cps. The pulse is wider above cut-off, cathode voltage is higher, and the oscillator is speeded up.

One other aspect of this circuit is worth noting. The ringing coil, *CD*, helps make this oscillator more immune to noise. In parallel with C309 (a 0.01 capacitor), it is shock excited by the oscillator and produces a sine wave. This is superimposed on the grid and combines with the normal waveform in such a manner that the grid is less susceptible to triggering by noise pulses. Figure 5-11 illustrates this condition. Waveform *A* shows the noise and normal grid voltage. The noise is of sufficient amplitude to cause the oscillator to start conducting before it normally would. Waveform *B* shows the sine wave generated by the stabilizing coil. Waveform *C* is the combination of normal grid waveform, stabilizing sine wave, and noise pulse.

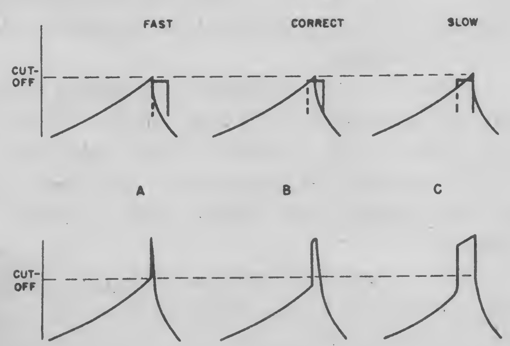


Fig. 5-10. Control tube grid-voltage waveforms for various frequency relationships between horizontal oscillator and incoming horizontal-sync signal. (A) Oscillator fast; (B) oscillator correct; (C) oscillator slow.

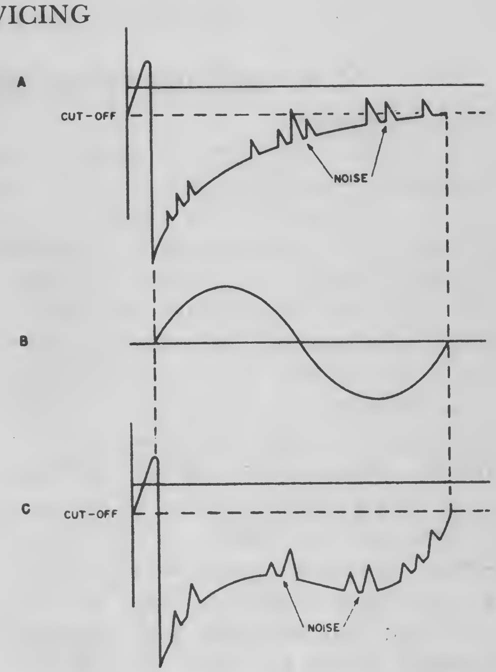


Fig. 5-11. Horizontal oscillator grid-voltage waveforms. (A) Basic grid-voltage waveshape with noise bursts; (B) sine-wave voltage developed across winding C-D of Z301; (C) resultant grid-voltage waveform with stabilizing circuit (winding C-D) added to BTO transformer. *Courtesy DuMont.*

This circuit has four controls. The horizontal hold is the front panel control, R247B; the horizontal coarse frequency control, slug of Z301; the horizontal phasing control, or "Wheel Adj.," which should be set with an oscilloscope for the waveform at J328, as shown in Figs. 5-8 and 5-12; and the horizontal locking range, C306A.

2. Troubles in Pulse Width AFC System. Loss of horizontal synchronization may result from any of the following causes:

(1) Defective V301.

(2) Changed characteristics (due to age) of V301, requiring readjustment of horizontal sync controls.

(3) Loss of sync pulse prior to V301A (see tubes V212, V214 in Fig. 5-4).

(4) Sync clipping in video system.

(5) Open C302 or C311.

(6) Changed value of C308, R306; C309, R303, and R304. Note that these last two resistors have a 5 percent tolerance.

(7) Leaky C301.

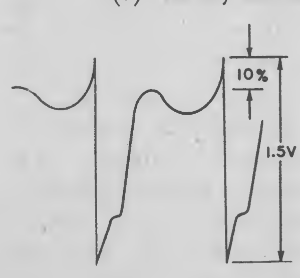


Fig. 5-12. Blocking oscillator waveform adjustment. *Courtesy DuMont.*

IV. TROUBLESHOOTING HORIZONTAL AND VERTICAL SYNC SECTIONS

A. General Techniques

The paragraphs in this section apply to general considerations in troubleshooting both or common sync sections. Information for specific models is also included under their respective headings as troubleshooting examples. Generally, the tubes in the suspected stages are checked first and the controls are adjusted as mentioned in preceding text. When the defect is not obvious, the scope is used to localize the trouble. The manufacturer's data is referred to for waveform and voltage comparison.

1. CONTROL ADJUSTMENT. Adjust the hold controls, using the procedure given in the preceding section. Also note the effects of the contrast and agc controls. Improper operation of any of these controls can often supply a hint as to which circuit is at fault. For example, poor horizontal hold may be caused by the horizontal sync circuit alone, when contrast and vertical hold controls operate normally. If the vertical hold is also poor, the trouble may be in the common sync circuits. When the contrast or agc control cannot be adjusted for a properly shaded picture, the trouble may be in the agc circuits.

2. COMMON SYNC. Trouble in the common sync stages will usually affect both horizontal and vertical frequency stability. When trouble is indicated in only the horizontal or the vertical sync circuit, it is advisable to start taking scope readings at the point where the sync enters the frequency control network and then work back through the sync circuits. However, for ease of understanding, the procedure outlined will assume that neither type of sync exists and start scope readings at the sync take-off point.

3. SYNC TAKE-OFF. The sync take-off point is the point in the video circuit from which the first sync tube receives its signal. This point may be anywhere from the video detector to the video output, including the d-c restorer circuit. Where a d-c restorer is used as the sync take-off, it can be treated as a preliminary sync circuit. At the sync take-off point (or the point feeding the d-c restorer where that is the sync take-off point) both the sync and video information are present. The level of the sync at this point should be at least 15 percent of the total waveform, with the scope sweep frequency set to view a complete frame. In many cases this will be found to be as high as 30 to 40 percent of the total (pin No. 1 of V107A in Fig. 5-14).

If trouble is encountered in the sync circuit, the vertical blanking bar should be investigated (Fig. 5-15). To do this, the brightness is advanced and the contrast level reduced while the picture is held as steady as possible, with the vertical blanking bar in view on the TV screen. If a normal blanking and vertical sync bar is present, it indicates that the trouble normally will be found in the sync circuits and not previous to the sync take-off point.

4. SYNC COMPRESSION. If the sync level is too low at this point, the trouble exists before the sync circuits. The trouble may be due to poor agc action; limiting in the i-f, r-f, or video amplifiers, caused by leaky capacitors; bad tubes (including picture tube); off-value resistors; or defective peaking coils or crystals. It is also possible for the trouble to be caused by improper alignment or poor reception.

5. VERTICAL SYNC. If vertical sync is out, the general procedure explained in the preceding text is followed.

6. HORIZONTAL SYNC. If horizontal sync is affected, the sync signal at the input to the horizontal control circuit is first inspected. This is pin No. 1 of V114 (Fig. 5-13). If this point compares favorably with the given waveforms, then the control circuit should be investigated. When an unfavorable waveform is obtained, the possibility of control circuit interaction must be explored first. This is accomplished by disconnecting C153 and rechecking the waveform. If the waveform is still bad, the sync circuits are then checked. Frequently, operation of agc circuits depends on horizontal oscillator action. Improper agc voltage may cause sync clipping in the video section. See "Miscellaneous Trouble Indications," paragraph C, at the end of this section.

B. Specific Examples of Troubleshooting Techniques

1. WAVEFORMS IN THE CROSLEY 411 CHASSIS. The Crosley 411 chassis (Fig. 5-14) uses one half of dual triode 6SN7 as a sync clipper and the other half as the sync output. A 36-v PP signal is obtained from the video output circuit. This signal, a composite of video and sync, is stripped of practically all the video information by the first triode section and fed to the second triode. A positive d-c voltage is fed to the grid of the second triode section to counteract the d-c voltage developed at the cathode. The positive 11v found at this point is normal. The important consideration is that this point is negative with respect to the cathode.

a. Phase Inverter. The output tube is not used for gain but to invert the phase of the signal used to trigger the vertical oscillator. This tube also supplies the horizontal phase detector with two signals of equal amplitudes, 180 degrees out of phase with each other.

b. Vertical Sync. A vertical integrator network consisting of R143, C134, R144, and C135 couples the vertical pulse to the grid of the vertical oscillator through the vertical blocking transformer. Since the oscillator voltage waveform developed at this point will tend to override the sync, it is advisable to re-

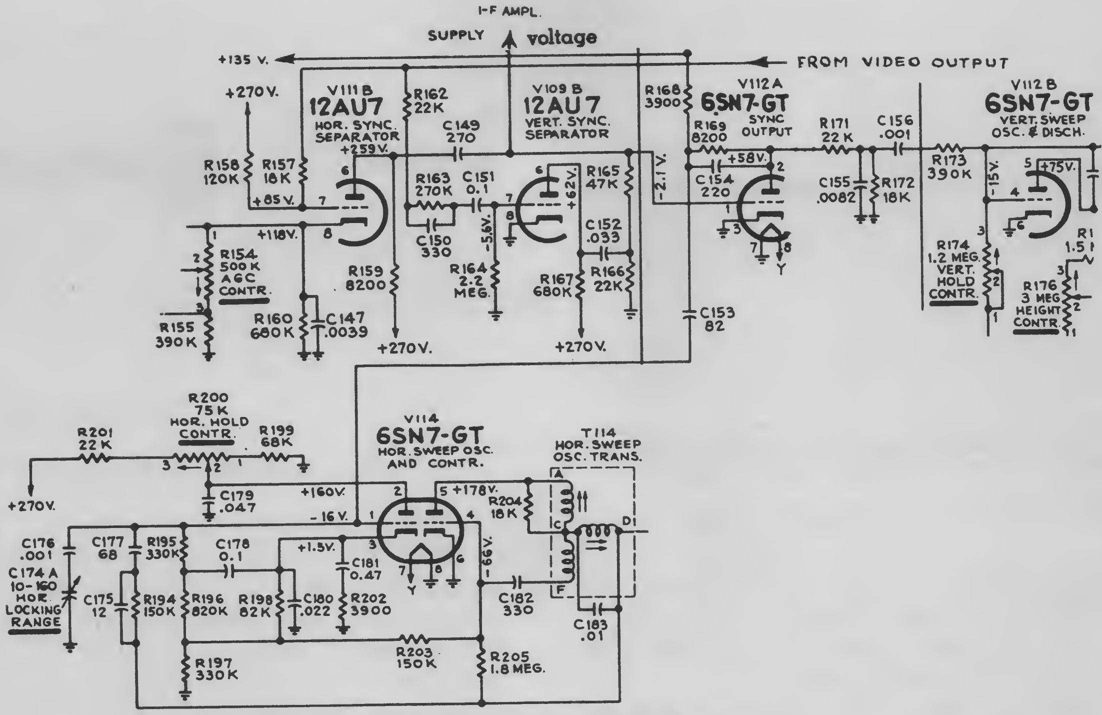


Fig. 5-13. Sync circuit: RCA KCS 78 chassis.

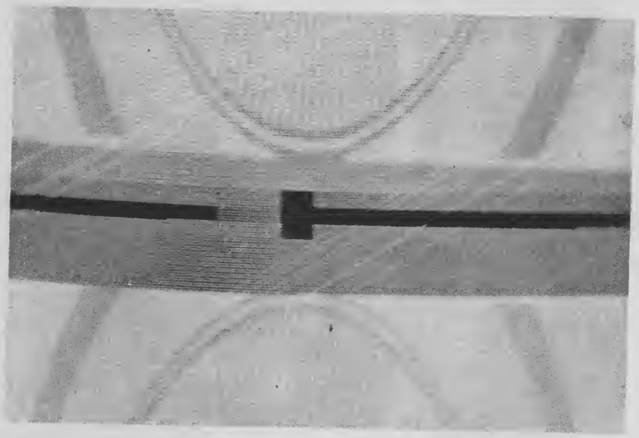
Fig. 5-14. Sync circuit: Crosley 411 chassis.

move the oscillator tube from the circuit or to disable the oscillator while viewing this sync waveform (Fig. 5-16).

c. Horizontal Sync. The scope is used to investigate the waveforms at pins No. 1 and No. 2 of V108, the 6AL5 horizontal phase detector. The waveshape at TP-5 is checked. This sawtooth wave is derived from the horizontal output transformer and shaped by R176, R162, R161 and C151, and C152.

d. Resistance and Voltage Checks. If incorrect waveforms were obtained at any point in the previous oscilloscope analysis, the particular circuit at fault should be investigated by voltage and resistance checks. If proper waveforms were obtained in the horizontal phase detector circuit and the trouble still exists, it is then necessary to make voltage and resistance checks in the phase detector circuit.

e. Phase Detector or Horizontal AFC. The cathode, pin No. 1, and the plate, pin No. 2, of the 6AL5 phase detector should develop +10v and −10v, respectively. These voltages cancel out at the junction of R159 and R160 when the oscillator is on frequency and does not require any correction voltage. The control voltage can be checked at this point by adjusting the horizontal hold or frequency, so that the oscillator falls out of synchronization both above and below operating frequency. The picture will remain in sync from +3.5v to −2.5v, but the actual range where the picture will remain locked-in, even after sync is temporarily disrupted, is only +2.5v to −1.5v. This voltage is then filtered and passed on to pin No. 4, the grid of V117A (horizontal oscillator).



Vertical blanking and sync signal in a normal receiver. This photo should be studied carefully. It was made with the vertical hold control adjusted to show the vertical blanking and sync.

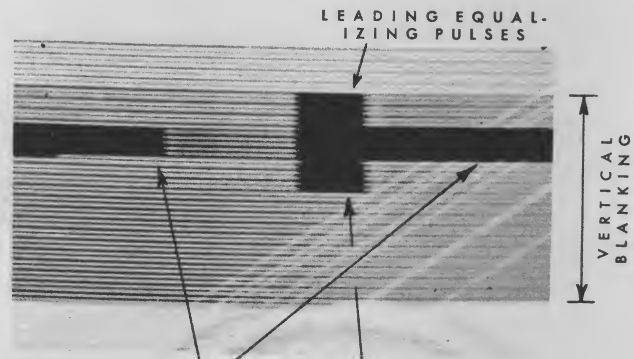


Fig. 5-15. Vertical blanking bar. *Courtesy RCA.*

The voltage variation at this grid should also be checked.

f. Signal Substitution. A synchronized cross-hatch generator or a video generator can be used to advantage by supplying constant vertical and horizontal sync pulses to a circuit under test.

g. VOM Servicing. In the home a VOM can be used to help trace sync trouble. D-C power supply voltages can be checked and d-c voltages generated by signal voltages can be checked. Good voltage indications will be obtained with a standard 20,000 ohms/volt VOM. Some voltages will be lower than shown on the diagram, because of the loading effect of the meter. Where a large resistance is in series with the B+ source (such as at pin No. 2, the plate of V107A), or at the point where the d-c voltage is developed across a large resistance (such as pin No. 1, the grid of the same tube), the voltage readings will be lower. Voltages such as that at pin No. 1 of V107A can be checked by noting the voltage with and without a received signal. Voltages developed by the phase detector can be checked at TP-3 with a drop of approximately 1v from normal. Due to the large resistance, R164 (feeding pin No. 4, the grid of V117A) voltage cannot be checked at this grid.

h. Locating Defects. Defective *vertical sync* alone will usually be caused by defects in the network from the point where the vertical sync is separated at pin No. 5 of V107B to the oscillator control grid. This includes R141, C133, R143, C134, R144, and C135. Hum introduced at any point through which the sync signal passes can also cause poor vertical sync. Typical fault is cathode-to-filament leakage in the r-f, i-f, video, or sync tubes (including the r-f oscillator and the CRT). When this condition occurs, there will be a tendency for the picture to lock-in vertically on the hum. The condition noted will be a fairly steady picture, with the vertical blanking bar visible on the screen above the top of the picture and below the bottom.

Defective *horizontal sync* alone can usually be traced to the horizontal afc circuit, which properly starts at the output of V107B and includes the comparison pulse, its shaping network, V108, and the filter network to the grid of V117A. A shorted capacitor, C151, will prevent V117 from oscillating. Shorting the grid (pin No. 4 of V117A) to ground or removing the 6AL5 (V108) from the receiver will permit oscillator operation when this trouble occurs.

Defective *combined horizontal and vertical sync* can be traced to defects in the sync clipper, sync output, sync take-off, agc, crystal detector, or to improper alignment or poor reception.

2. TROUBLESHOOTING THE RCA KCS78 CHASSIS. The RCA KCS78 chassis uses two 12AU7 triode sections as sync separators. One triode (V111B, Fig. 5-13) is for horizontal separation, and the other triode, V109B, is for vertical separation. The two sync outputs are combined and fed into a sync output tube. Two networks in the output tube plate circuit then separate the vertical and horizontal sync pulses and feed them to their respective oscillator circuits. This is a novel circuit which permits selective sync separation and thereby accomplishes this separation to a higher degree.

a. Basic Procedure. The basic troubleshooting procedure involved in the KCS78 sync system is the same as that previously discussed. Here, however, two different points of dual sync circuits exist. These are the individual sync circuit channels V111B (horizontal) and V109B (vertical) and the high-pass network (R169, C154, and C153), plus the oscillator control circuit for horizontal and the integrating network (R171 and C155) for vertical.

Fig. 5-16 Vertical sync viewed at integrator output with oscillator disabled.

b. Vertical Sync. The vertical sync separator is capacitively and resistively coupled to the video output tube (Fig. 5-13). Waveforms can be checked at the grid and plate of this tube (V109B), at the grid of the sync output tube, and at the grid of the vertical oscillator. For a better waveform indication the vertical oscillator is disabled. This can be accomplished by removing the vertical sweep output tube. However, in this particular circuit, oscillator action need not be disrupted. A good waveform check can be obtained at the junction of C156 and R173. At this point a vertical sync pulse of approximately 20v combines with a vertical sawtooth wave generated by this plate-coupled vibrator (approximately 20v) to form a 30-v signal. If the proper vertical sawtooth wave is present at this point, the following assumption can be made. Namely, the circuit feeding this signal from the oscillator grid will also be capable of feeding the sync pulse back to this grid.

c. Voltage Checks. A voltmeter can be used, to check for the presence of B+ power supply voltages at the proper points in the sync circuit. It should be noted, however, that the grids of both V111B and V112A are tied in to B+ voltage points.

If a scope is not available, a voltmeter can be used to indicate the presence of sync signal. For a definite indication the signal path should be broken at a previous stage while changes in voltmeter readings are obtained. At pin No. 7 of 109B a reading of from —50v to 60v can be obtained on either a VTVM or a VOM. As much as 30v ac can also be obtained at this point with a VTVM. At pin No. 6 of V109B the VTVM will read up to 30v ac and a VOM will indicate 4v output on the 50-v output range. At pin No. 1 of V112A the VTVM shows 15v ac.

It should be noted at this point that the voltages given are for this particular circuit only. However, the method outlined can be used to advantage on numerous other circuits.

d. Horizontal Sync. Defective horizontal sync alone will usually be traced to the horizontal oscillator control circuit and the high-pass filter (R169, C154, and C153). The horizontal sync separator, V111B, also supplies control voltage for the agc amplifier. Therefore, a defect in this circuit normally will also affect video information. This, plus the fact that horizontal sync sufficient to hold the picture will be passed by the vertical sync separator, reduces the possibility of horizontal sync trouble being traced to V111B.

e. Pulse Width Horizontal Sync. The frequency of the horizontal oscillator is controlled by the action of the combination of a sync pulse and a sawtooth wave from the horizontal oscillator. When this circuit is inoperative, the signal voltage interaction interferes with scope analysis. Therefore, C153 and C177 are disconnected from pin No. 1 of V114, and waveforms are taken at the open ends of each. A horizontal saw of approximately 70v should be present at C177, with a 20-v pulse at C153 (see Fig. 5-17). It is possible to get good waveforms by just disconnecting one of the above capacitors, but the amplitudes and shapes will be modified. At this point C153 and C177 should be checked for leakage. A d-c voltmeter connected between the open end of either capacitor and ground will read positive voltage if the capacitor is leaky. Next, B+ voltages and resistances are checked. Winding C-D of T114 and C183 may be temporarily shorted out with a jumper while troubleshooting, to determine the possibility of trouble in this circuit.

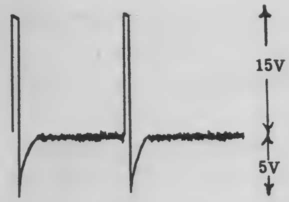


Fig. 5-17. Horizontal pulse-width sync pulse alone.

It has been noted that the operation of all the afc circuits is based on a d-c control voltage produced by a frequency comparison circuit. Checking for the presence of this control voltage as the system is varied through its operating frequency supplies a very good indication for localizing a sync trouble. If the proper control voltages are not present, then the circuit being controlled must be investigated.

After all the preceding checks have been made, it becomes necessary to check individual parts. Where proper equipment is not available for some of these checks, parts substitution should be tried.

f. Combined Vertical and Horizontal Sync. The only common sync channel is the circuit associated with the sync output tube, V112A. Therefore, common sync troubles can be caused by defects in this circuit. Other reasons for common sync troubles include the agc, r-f, i-f, and video circuits.

C. Miscellaneous Trouble Indications

1. GENERAL. Defects in the horizontal or common sync circuits may cause agc troubles in some sets. A d-c voltage may be obtained from the sync circuits to establish the agc voltage level, either directly or indirectly. In the RCA KCS78 (Fig. 5-13) this point is at pin No. 8 of V111B, the cathode of the horizontal sync separator. In another type of agc circuit the circuit action depends on the synchronization of horizontal sync pulses with the pulses from the horizontal sweep circuit. In either case, circuit changes caused by improper agc voltages will affect waveform readings. When the circuit defect is not obvious with voltage and resistance readings, an external bias supply can be used to stabilize the r-f and i-f circuits so that a scope can be properly used. If a properly

locked-in picture is obtained with this bias box, the trouble is probably not in the sync circuits.

2. SYMPTOMS. When troubleshooting sync circuits, the information contained on the face of the CRT will help to isolate defects. Therefore, this information should be carefully studied while adjusting the hold controls and noting the effects. The visual symptoms for sync troubles, many of which are enumerated below, can be used to determine the reason for the defect.

a. Momentary picture with weak or no horizontal lock-in action usually indicates a properly operating oscillator circuit with a defective sync or frequency control circuit. If the picture cannot be locked-in instantaneously, the defect is in the oscillator circuit itself or is due to an excessive control voltage developed by the frequency comparison circuit.

b. Unstable picture horizontally can be caused by many things. A voltage arc, a microphonic tube, a poor solder connection, or an interfering noise pulse can cause a few horizontal lines to be unstable or cause the entire picture to be jumpy in a horizontal direction. Noise-limiting circuits and causes for arcing (such as corona, defective insulation, high-voltage capacitors, or tube breakdown) must be investigated.

Weak sync will also cause an unstable picture. This condition can be caused by defective sync or afc circuits, or by sync compression due to r-f, i-f, video, or agc defects. Interference and weak or ghosty reception will also cause the picture to be unsteady.

Pulling or bending of the picture shows up as twisted objects, such as doorways or windows. This condition may be due to hum in the raster itself. This should be investigated first by checking for straight edges on the raster. Sound or picture information remaining in the sync signal, or hum introduced at any point in the receiver that passes the sync signal, will also cause pulling. This includes poor filtering of the d-c control voltage of the afc circuit.

"Flag waving," or instability at the top of the picture, may be caused by an interfering signal (internal or external), causing jitter in the sync signal; or by an open antihunt circuit (Fig. 5-13, C181 or R202).

To help in localizing this trouble, the sync can be removed temporarily from the horizontal circuit and the picture held momentarily with the hold control. The picture is then checked for bending. If bending is present at this point, it is not due to the sync, but rather, to the afc or sweep circuit.

c. Frequency drift is caused by some component in, or associated with, the frequency-determining circuits that change value gradually with heat. This can be a tube, a capacitor, a coil, a resistor, or an adjustment control (such as a trimmer or a potentiometer). The servicing procedure used here involves parts substitution. Suspected parts may have heat applied to them, one at a time, from a cold start, to note frequency variation. Heat may be applied by focusing a spot light on, or bringing a soldering gun close to, the suspected part. Care must be exercised in this process, to prevent the destruction of good parts.

d. Improper horizontal phase does not cause much difficulty until it becomes excessive. This is due to the fact that a slight condition can be hidden behind the edges of the mask. The reactance type of horizontal afc circuit shown in Fig. 5-5 incorporates a phase adjustment in the oscillator coil, T108. Improper phase can be caused by a defect in C168 or in winding D-E-F. However, adjustment of the phasing slug is attempted first. In other types of afc circuits the comparison pulse fed back from the sweep circuit can be at fault. Some origin points of comparison pulse are illustrated in Fig. 5-7, winding 7-8-10 of T8, the horizontal deflection transformer; and in Fig. 5-8, tap D of Z301, the horizontal oscillator transformer. A phasing defect may be localized to any component from the pulse source through the shaping network to the 6AL5 plates in Fig. 5-7, or to the grid of V301A in Fig. 5-8. Other causes for phasing defects include improperly shaped sync pulses due to sync circuit defects, and slow retrace time due to horizontal output circuit constants. Slow retrace time may be caused by improperly matched deflection transformers or yokes, excessive capacity across the transformer, stray pick-up, or long yoke leads.

V. PREVENTIVE MAINTENANCE AND PARTS REPLACEMENTS

A. Preventive Maintenance

The technician can perform certain checks after a repair job, in order to decrease the possibility of future sync trouble.

1. The waveform, the phasing, and the ringing coil should be adjusted according to instructions in preceding text.

2. The hold in sync range of both the vertical and horizontal hold controls should be checked.

3. The receiver should be operated long enough to permit checking for frequency drift or for component failure after reaching operating temperature.

4. Microphonics and intermittents should be checked by tapping. In some receivers it is normal for the horizontal oscillator to be slightly microphonic.

5. Physical inspection may be made for overloaded resistors, damaged coils, and poor solder connections or other possible sources of arcing or corona.

6. The agc should be properly adjusted for the antenna to be used with the receiver. The antenna should be checked for corroded contacts and for frayed, broken, or improperly anchored lead-in wire.

B. Parts Replacement

In frequency-determining circuits, zero or temperature-compensated parts should be used when making replacements. It is advisable to adhere to the manufacturer's specifications when replacing parts. Some conditions caused by using replacement parts of wrong value are: unbalanced circuits, reduced effect of noise limiters or sync clippers, reduced range of sync lock-in action, horizontal phase shift, frequency drift, voltage breakdown, and unsteady picture.

CHAPTER 6. VIDEO SECTION SERVICING

I. OPERATION OF VIDEO SECTION

A. Introduction

1. FUNCTION. In the video section the picture i-f signals are amplified and detected. The resultant video signal is amplified and applied to the grid or cathode of the CRT, where it acts to intensity-modulate the electron beam. The four major circuits of the video section are:

a. Video i-f amplifiers and video detector.
b. Video amplifier and d-c restorer (when used).
c. CRT.
d. AGC.

In the discussion of these subsections in paragraph B, consideration will be given to causes of troubles in specific circuits. However, the general trouble-shooting procedure for the over-all video section will be given in "II. Troubleshooting the Video Section." Some repetition may result, therefore, but this is considered necessary in order to clarify some aspects of operation, while simplifying the application of these principles in troubleshooting.

2. INPUT SIGNALS, OUTPUT SIGNALS, AND FREQUENCIES. Each of the subsections is characterized by a unique input and output signal.

a. Pix I-F Amplifiers and Video Detector. The *input signal* is an a-m picture carrier with its attendant sidebands. In the intercarrier system now used almost universally, there is also present the f-m sound i-f carrier. These carrier frequencies, 4-5 mc apart, are in the 20- or 40-mc band. The present trend in receivers is to use 40-mc i-f frequencies, since in this range there is a minimum of interference from picture and sound i-f harmonic. Image rejection is improved and local oscillator interference is reduced.

The i-f amplifiers and the input to the video detector are tuned to accept both carriers and their modulation.

The *output* of the video detector is the composite video signal and the newly created 4.5-mc f-m sound carrier. The f-m signal may be trapped-out here or in the output of the video amplifier, and then routed to the sound i-f system. The composite video signal is fed to the video amplifier.

b. Video Amplifier and D-C Restorer (When Used). The range of frequencies of the composite video signal may vary from 20 cps to 4 mc, depending on the detail in the picture. The video amplifier increases the amplitude of this signal so that it is effective in intensity-modulating the electron beam as it traces out the picture on the CRT.

The d-c restorer, if used, automatically controls the brightness level of the CRT by insuring that all blanking pulses will be lined up when applied to the CRT. It operates on the sync pulses in the composite video signal.

c. The CRT. The input signal to the video amplifier (and the d-c restorer, if used) and up to the grid or cathode of the CRT is the video signal. The CRT converts this into variations of light and dark. The result of properly synchronized deflection of the CRT beam, and its intensity-modulation by the video signal, is the picture seen.

d. AGC Circuits. The input to the agc circuits will vary with the type of agc used. Generally speaking, the input is the composite video signal or sync pulses. In the case of keyed agc, a pulse from the horizontal output transformer is used, in addition to the video signal.

The output is a negative d-c voltage which is proportional to the peaks of the synchronizing pulses. This d-c voltage usually biases two of the i-f amplifiers and the r-f amplifier.

B. Circuit Comparison of Late TV Receiver Models

1. PICTURE I-F AMPLIFIERS AND VIDEO DETECTOR. Analysis of late models of TV receivers shows great similarity in the design of pix i-f amplifiers and detectors. Thus, all the receivers examined use either three or four stages of i-f amplification. The 6CB6 is used as an i-f amplifier in 87 percent of the receivers checked. Two additional types used are the 6BA6 and 6CF6.

Seventy percent of the receivers used overcoupled (transformer-coupled) i-f stages. The remainder use stagger-tuned, or a combination of stagger- and transformer-tuned circuits.

Fifty percent of the receivers used i-f frequencies in the 40-mc frequency band, while the remainder were in the 20-mc band.

Sixty-seven percent of the receivers use germanium diodes as video detectors, with the 1N64 as the most popular type. The 1N60 and the 6AL5 tube accounted for the remainder.

The first and second video i-f amplifiers are controlled by agc in 94 percent of the receivers. The output of all the detectors is a negative-going composite video signal.

a. Stagger-Tuned Video I-F's and Detector. Figure 6-1 is the schematic diagram of the pix i-f and detector circuit used in the GE Model 21T1 chassis. This is typical of circuits employing stagger-tuning for the i-f's. Other receivers using similarly coupled circuits are CBS-Columbia Model 1027, and Raytheon Model 17T1.

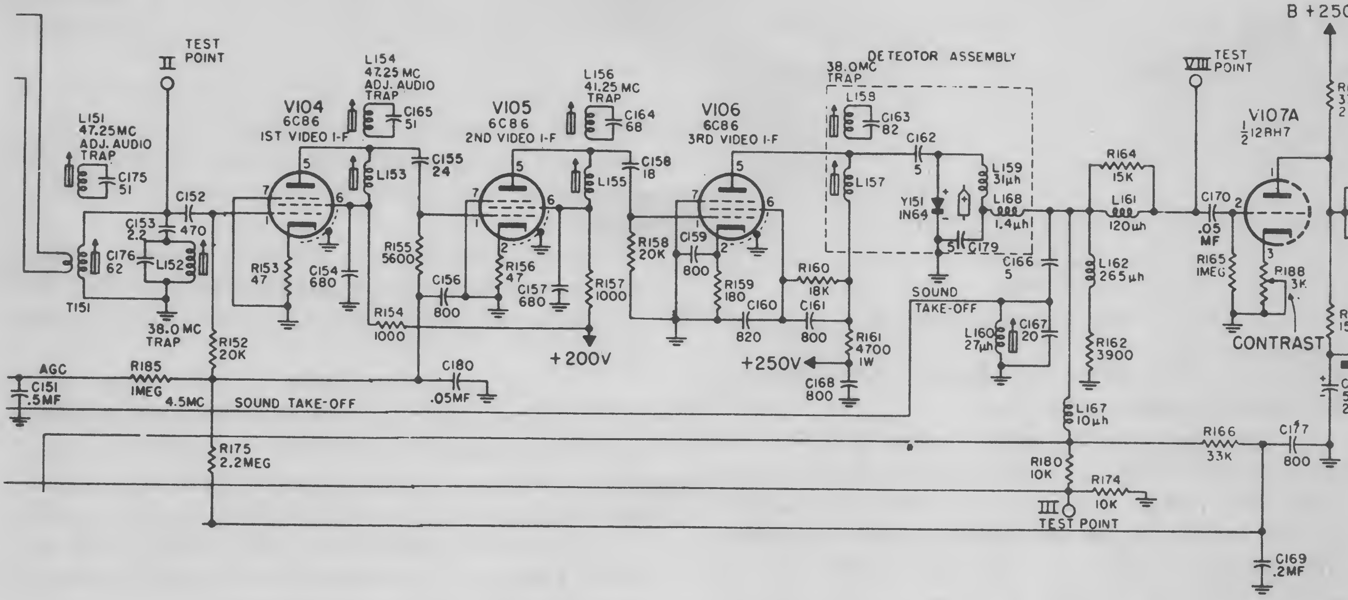


Fig. 6-1. Video i-f's and detector: GE Stratopower chassis.

V104, V105, and V106 make up the three i-f amplifiers, each utilizing the 6CB6, a high-gain pentode. These operate as Class A amplifiers. The first two are biased by an agc voltage developed by the agc circuits. In the absence of signal (hence, in the absence of agc bias) these two tubes are biased by the voltage developed across their unbypassed cathode resistors. V106 is self-biased (cathode biased).

The i-f sound carrier is 41.25 mc, and the i-f picture carrier is 45.75 mc.

Alignment of the i-f's is accomplished by proper tuning of T151, L153, L155, and L157; and the traps labeled L151, L152, L154, L156, and L158. Proper technique for aligning this circuit will be explained under "Alignment."

Traps are used in most i-f systems. The usual traps found are described in (1) and (2) below:

(1) *Lower Adjacent-Channel Sound Trap.* In this receiver L151 and L154 are the lower adjacent-channel sound traps. They are absorption traps and are tuned to produce minimum pix detector output at 47.25 mc. This is the frequency created by the beating of the sound carrier of the lower adjacent channel with the desired-channel local oscillator signal. This frequency would interfere (create sound bars) with proper reception in an area where the interfering adjacent-channel signal was strong and the desired-channel signal weak. It is eliminated by the absorption trap.

This trap can be identified by the fact that it is 6 mc *above* the i-f sound carrier.

(2) *Upper Adjacent-Channel Picture Trap.* This absorption trap is identified by the fact that it is 6 mc *below* the i-f picture carrier. It reduces possible interference from the beat note between the pix carrier of the upper adjacent channel and the local oscillator of the desired channel. The normal frequency for this absorption trap in the GE i-f system would therefore be 39.75 mc (see Fig. 6-2). No such trap appears in the diagram. The closest to it are the 38-mc traps, L152 and L158. Therefore, 38 mc actually becomes the upper adjacent-channel picture-carrier trap frequency under conditions of fringe tuning, where this type of interference is prevalent. Here, in tuning the station for maximum picture gain, the desired-channel video i-f carrier is placed near, or at the top of, the i-f response curve, 44 mc

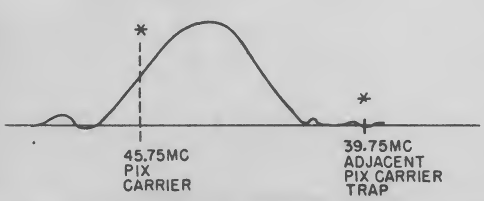


Fig. 6-2. Normal tuning with 39.75-mc trap. *Courtesy GE.*

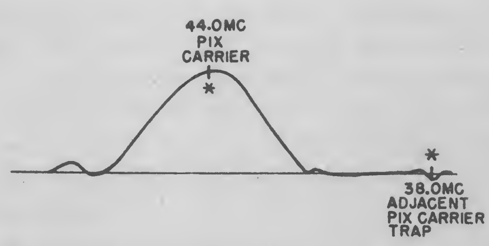


Fig. 6-3. Fringe tuning showing 38-mc trap. *Courtesy GE.*

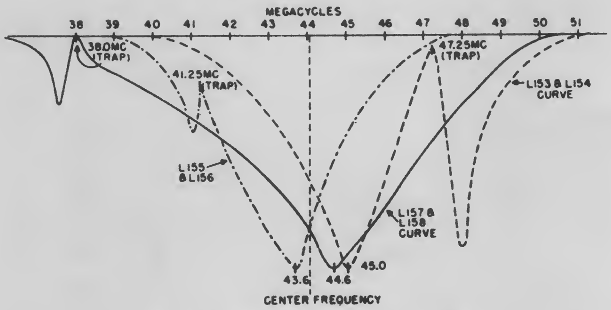


Fig. 6-4. Video i-f curves. Courtesy GE.

in this case (Fig. 6-3). Accordingly, 38 mc becomes the adjacent-channel video trap.

An additional trap found in the GE is L156. The purpose of this trap is not to remove the sound i-f carrier, but rather, to provide the means for adjusting the sound i-f carrier to its proper amplitude. This prevents 4.5-mc "crystallization" effects in the picture when the receiver is tuned for best picture detail.

Figure 6-4 shows the response curves for each of the i-f tuned circuits in this receiver. Figure 6-5 illustrates the resultant i-f response curve.

The crystal (IN64) diode, Y151, detects the i-f video carrier and its modulation, and the result is the negative-going composite video signal, which is fed through C170 to the grid of first video amplifier, V107A.

The output of the detector is also the sound takeoff. Here, the 4.5-mc f-m subcarrier, created by the heterodyning of the pix and sound i-f carriers, is coupled by the 4.5-mc tuned circuit, L160 and C167, and fed to the sound i-f amplifier.

b. Transformer-Coupled Pix I-F Amplifiers and Video Detector. Figure 6-6 is the schematic diagram of the video i-f amplifiers and video detector, used in the DuMont Teleset RA162. This is typical of overcoupled i-f stages used in the following receivers: Capehart CX-36, Emerson Model 727D, Hoffman Model 7M124, Magnavox Model MV106, RCA 17T301, and Zenith Model 19L27. All the receivers listed employ i-f's in the 40-mc range.

The following receivers use transformer-coupled i-f's whose frequency is in the 20-mc range: Crosley Model 385, Hallicrafter AR1200D, Motorola 21T4AC Stromberg-Carlson Model 521, and Wells-Gardner Model GS-40.

The frequencies which are amplified and detected by the circuit in Fig. 6-6 are: the 45.75-mc picture i-f carrier and its attendant modulation; and the 41.75-mc sound i-f carrier and its modulation. There are four stages of i-f amplification utilizing the 6CB6. One half of a 6AL5 is used as the video detector. The cathodes of the first two i-f amplifiers are unbypassed, introducing enough degeneration to minimize changes in the input impedance of these two tubes (Miller effect). These two stages are controlled by the agc bias.

I-F transformers Z207, Z202, Z203, and Z204 are shielded. In addition to transformer coupling, small gimmicks from primary to secondary of each of the transformers act as couplers to broaden the bandwidth.

The following traps are found in these i-f circuits and operate in the same manner and for the same purpose as the traps previously described in the GE chassis.

(1) *Lower Adjacent Sound Trap, L214, L201.* These traps are connected to low-impedance taps in the secondaries of Z207 and Z202, to reduce their loading effect on the grid circuits and to minimize radiation of the adjacent-channel sound signal.

(2) *Accompanying Sound Traps, L202 and L213.* These are adjusted to set the sound carrier at about 5 percent on the response curve.

The manufacturer has specified that some of the components in these circuits are critical and require exact replacement. These are screen bypass capacitors, C203 and C239. Improper size or dress may result in i-f amplifier instability or oscillation. The following series-combination screen dropping resistors should not be replaced by a single resistor: R237 and R232, R207 and R209, and R213 and R212. This also applies to R214 and R291, the plate decoupling resistors in V202.

c. Identifying Characteristics

(1) *Stagger-tuned* i-f's are identified by the fact that single-tuned coils are used between stages, and that each coil is peaked at a different frequency. The result of adding the response of each stage makes up the over-all i-f response curve.

(2) *Transformer-tuned* i-f's use double-tuned transformers between stages. The tuning of these overcoupled stages is specified by the manufacturer to give the over-all response required.

d. Possible Troubles in I-F Amplifiers and Video Detector. Despite the differences in interstage coupling in the two types of circuits currently used,

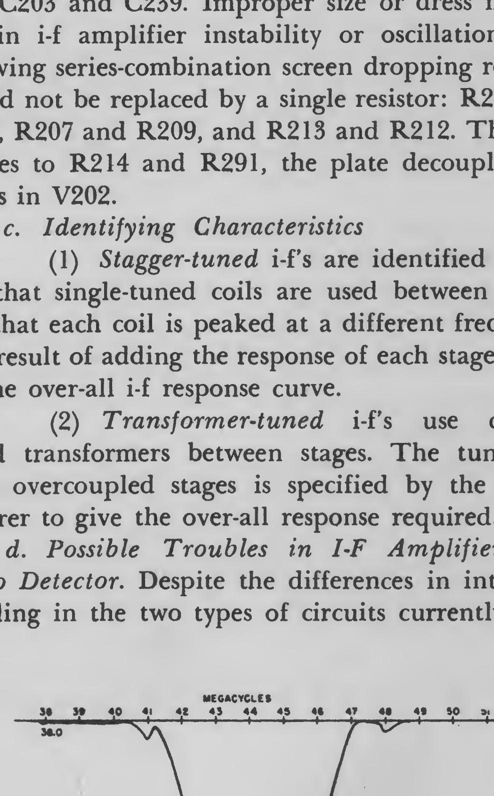


Fig. 6-5. Resultant i-f. Courtesy GE.

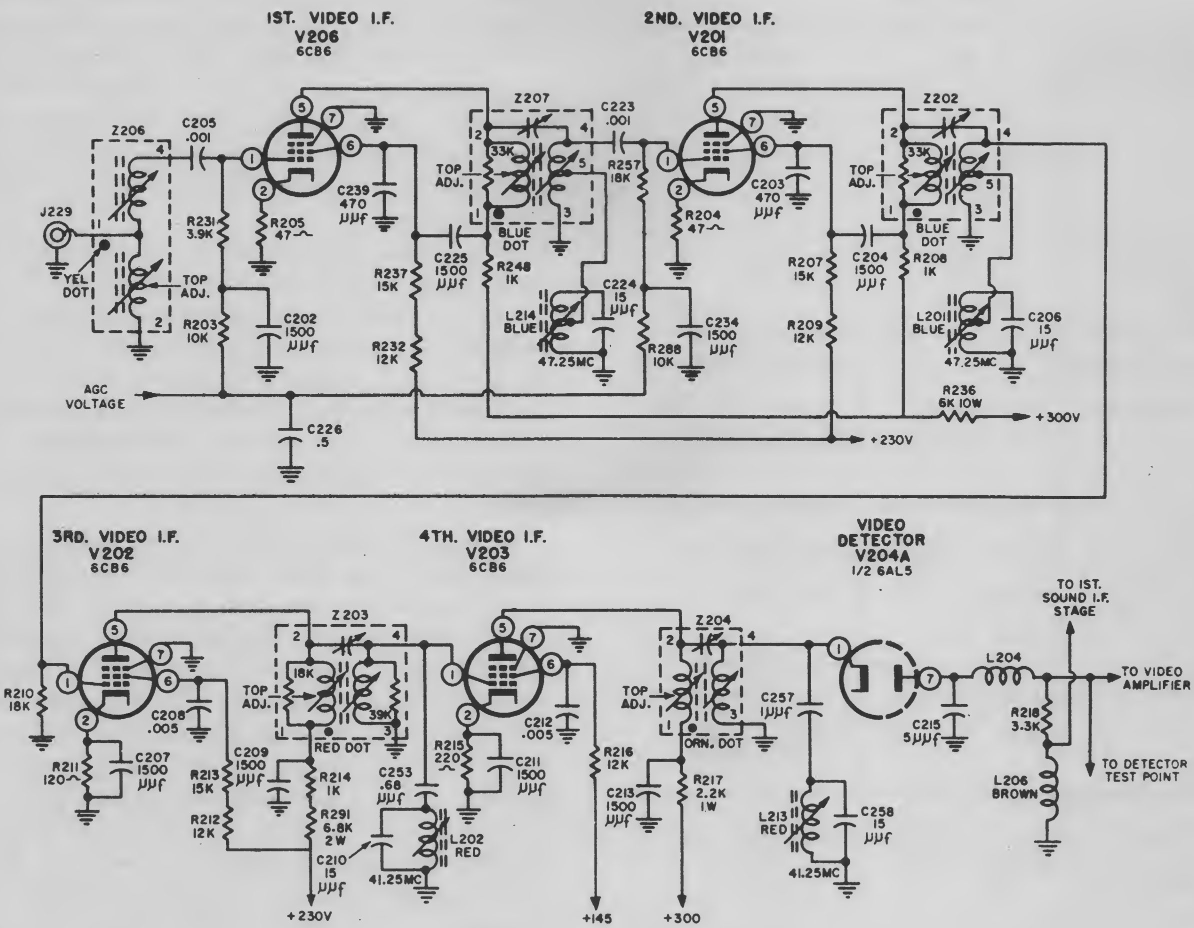


Fig. 6-6. Schematic diagram of video i-f stages and the video detector: DuMont RA162.

servicing problems are very similar for both. A listing of defects and possible troubles indicates this.

(1) *No picture, no sound, raster OK.* In either type of i-f, this condition may be due to a complete break in the signal path of the two i-f carriers. It could therefore result from defects in any of the i-f amplifiers, detector, video amplifier, or front end. Possible i-f causes are shown in the table on page 72.

(2) *Hum in picture, hum in sound, poor vertical sync.* Heater-to-cathode leakage in the i-f amplifier tubes may cause this. Trouble may also be due to a similar defect in local oscillator or other front-end tubes.

(3) *Picture and sound flutter or motorboat.* AGC defect or improper alignment causing instability is the cause of this condition.

(4) *Negative picture – poor sync.* AGC trouble or oscillation in or overloaded i-f's causes this. In addition, the IN64 may be wired in reverse in the GE chassis, causing similar symptoms; or leaky gimmicks as used in DuMont interstage i-f transformers; or gassy i-f tubes.

(5) *Weak picture, sound weak or OK.* Weak tubes; increase in value of cathode resistors; leaky decoupling capacitors in screen grids; low plate and screen voltages; all are sources of this trouble.

(6) *Loss of picture detail, or smearing.* This is caused by improper alignment; change in value of plate dropping resistors or detector load resistor.

2. Video Amplifiers and D-C Restorer. Comparison of video amplifier circuits in late models shows striking similarities and some differences. Of 17 receivers checked, 12 use one stage of video amplification; that is, the output signal is coupled to the cathode of the CRT. Five of the receivers employ two stages of video amplification. Here, the output signal is coupled to the grid of the CRT.

Only one of the receivers employs a d-c restorer. The others do not. Of these, two do not require d-c restoration because direct coupling is used from video detector to video amplifier to CRT. Vertical retrace blanking is used in 12, while 5 are without blanking facilities.

In 14 of the receivers, the contrast control appears in the cathode of the video amplifier and varies the gain of that circuit. The other contrast controls are in the plate circuit of the video amplifier. The set-

TABLE III

Defective Tubes	GE	DuMont
	V104, V105, V106, Y151 (1N64)	V206, V201. V202 V203, V204A
Open coupling capacitors	C152, C155 C158, C162	C205, C223
No or low screen or plate voltage due to:	Open coils L153, L155, L157	Shorted primary to secondary in Z207, Z202, Z203, Z204
	Shorted screen bypass capacitors C154, C157, C160, C161	Shorted screen by-pass C239, C203, C208, C212
	Open resistors R154, R157, R161, R160	Open screen or plate dropping resistors
AGC troubles causing excessive bias on:	(Open B+ bus) V104, V105	(Open B+ bus) V201, V206

ting of these controls determines the amplitude of the video signal fed to the CRT.

A wide variety of tubes is used as video amplifiers. Included are: 6X8, 6AQ5, 12BH7, 6AH6, 6AG7, 6CB6, 6CL6, 6U8, 6W6, 12AT7, and 12BY7. The most commonly used are the 6AH6, 12BH7, and 6CB6.

a. Single-Stage Video Amplifier. Figure 6-7 is the schematic diagram of the video detector and video amplifier used in RCA chassis KCS 72-72A. The video amplifier is typical of those receivers using a single stage of video amplification. Included in this group are the Crosley 385, DuMont RA160, Emerson 727D, Hallicrafter AR1200D, Hoffman 7M124, Magnavox MV106, Motorola 21T4AC, RCA 17T301, Raytheon 17T1, Zenith 19L27, Admiral 19K, and Admiral 22F2.

The negative-going output of the video detector, V109A, is coupled directly to V110, a 6AC7 used as a compensated video amplifier. The amplified positive-going signal is coupled directly to the cathode of the CRT, eliminating the need for a d-c restorer. The contrast control, R137, appears in the plate circuit of V110. It sets the amplitude of video signal coupled to the CRT.

The pix detector uses an unconventional circuit arrangement. The cathode and grid of V109A act as a diode for video detection. The cathode and plate of the same tube act as an agc detector. The pix detector is a compensated circuit. The sound take-off is across L102 in the detector load. L103, the 4.5-mc trap, excludes the new 4.5-mc sound i-f from the video amplifier.

The peaking coils in the pix detector and video amplifier are L101, L102, L104, and L105.

b. Two-Stage Video Amplifier. Figure 6-8 is a schematic diagram of the video detector, video amplifier, and CRT used in the Capehart CX36. The amplifier used here is typical of two-stage amplifiers used in these late receiver models: CBS-Columbia 3100A, GE 21T1, Stromberg-Carlson 521, and Wells-Gardner GS-40.

The negative-going composite video signal (2v PP output) from the 1N64 used as video detector, is directly coupled to the grid of V205A. This is one half of a 6X8 acting as the first video amplifier. An amplified signal (gain of the V205A is about 5), whose phase has undergone a 180-degree reversal through the tube, appears in the plate and is capacitively coupled to the grid of V206, the video output tube. Since a positive-going video signal is applied to the grid of V206, a negative-going amplified composite video signal appears in the plate of V206 and is coupled by C230 to the grid of the CRT. The PP voltage of the signal at this point is about 110v. The gain of the second video amplifier is therefore about 12. The over-all gain of both video amplifiers is about 60, and they provide sufficient video drive for the CRT.

Both the video amplifiers and the pix detector are frequency-compensated. The compensating or peaking coils are L212, L213, L205, L206, L214, L210, and L209.

The contrast control is a variable 1.5 K resistor, R224, in the cathode of V206. It is in series with the parallel combination, R225 and C602C, thus adjusting the bias, and therefore the gain of V206.

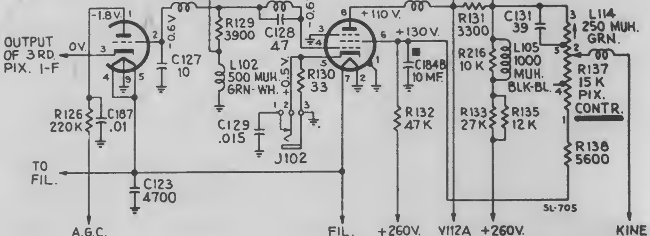


Fig. 6-7. Pulse detector and video amplifier: RCA KCS 72.

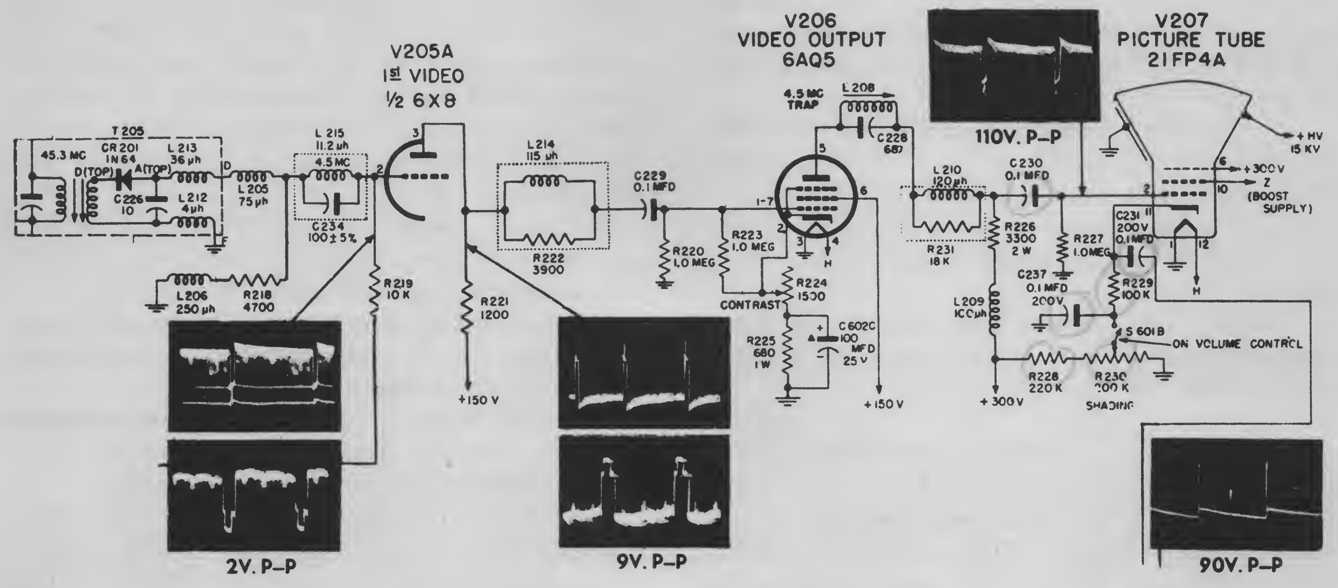


Fig. 6-8. Video detector, amplifier, and CRT: Capehart CX36

Degeneration of the video signal is also accomplished across this unbypassed resistance.

Rejection traps, L215 and L208, keep the f-m sound signal out of the grid of the CRT.

The switch, S601B, which is controlled by the "On-Off" switch, opens the cathode of the CRT when the set is turned off, and thus eliminates afterglow on the picture tube.

c. Identifying Characteristics. The video amplifier is identified by the fact that it receives the composite video signal from the video detector. Each stage of video amplification causes a 180-degree phase inversion in the video signal. The video output tube feeds the grid or cathode of the CRT. If the signal goes to the grid, it must be negative-going. (Sync pulses are then the most negative portion of the signal.) If it goes to the cathode of the CRT, it must be positive-going.

Two types of coupling are employed in these stages; either direct or capacitive.

d. Possible Troubles in the Video Amplifier. Component failures are the usual causes of trouble in these circuits.

(1) *Weak or defective video amplifier tubes* give rise to flat weak pictures, poor sync, or no picture. Depending on the position of the sound take-off, sound may or may not be affected by troubles in the amplifiers.

(2) *Defective peaking coils* are a frequent source of trouble. The efect of a defective coil will depend on its position in the circuit, the nature of the trouble, and whether or not it is paralleled by a loading resistor.

Table IV lists the effects of defective coils in Figs. 6-7 and 6-8.

TABLE IV

Peaking Coil		Defect	Effects on Receiver Operation
Fig. 6-7	Fig. 6-8		
L101, L102	L213, L205 L206	Open	No picture, no sound.
L104 L114	L209	Open	No picture.
L105	L210 L214	Open	Loss of high video frequencies, resulting in reduced picture detail.
L102	L206	Shorted	No sound, reduced picture detail.
All coils	All coils	Shorted	Reduced picture detail.

In addition to the effects noted in the table, defective coils in the d-c plate circuit, which are paralleled by resistors, may result in possible increased contrast, due to increased low-frequency response. This leads to smearing and trailing whites, with accompanying loss of picture detail. It should be noted further that peaking coils are likely to open much more frequently than to short out.

(3) *Open cathode resistors* will lead to complete loss of picture. Increased-value cathode resistors will lead to a poor contrast picture and possible sync difficulties.

(4) *Shorted screen bypass capacitors,* if shorted (C184B in Fig. 6-7), will result in a complete loss of picture.

(5) *Open contrast control* may result in complete loss of picture.

(6) *Leaky coupling capacitor to CRT,* if C230 (in Fig. 6-8) is leaky, may cause blooming.

(7) *Changed-value and open plate and screen resistors* are a possible source of trouble. Open

plate-load or screen dropping resistors will result in loss of picture. Changed-value resistors may cause weak, flat picture or a very contrasty picture lacking fine detail.

(8) *Open interstage coupling capacitors* will cause complete loss of picture. Also, *leaky* coupling capacitors may cause sync or video clipping.

(9) *Open video amplifier grid resistor* may cause complete loss of picture or picture fading in and out.

(10) *Filament-to-cathode leakage in video amplifier* may cause hum in the picture and possible hum in sound.

3. Types of CRT's. A wide range of CRT's is used in the late models of TV receivers. Tube sizes include 17-in., 20-in., and 21-in. Tube types found are: 17CP4, 17DP4, 17HP4, 17KP4, 17LP4, 20HP4A, 21EP4, 21FP4, 21YP4, and 21ZP4. All are glass rectangular, with the exception of 17CP4, which is a metal tube.

The trend is for the use of low-voltage electrostatically focused CRT's. Of the sets checked, most CRT's employ electrostatic focusing, and some magnetic focusing. The magnetically focused tubes are the 17CP4, 21EP4, 17YP4, and 21ZP4. Some of the electrostatic tubes are self-focusing and require no control. Others employ a potentiometer for focusing. Some manufacturers use different voltage taps to which the focusing anode may be connected for varying conditions.

Mechanical (magnetic) centering devices are used extensively. A new type of dual, magnetic, ring-centering device simplifies centering adjustments.

Raster correction magnets (pin-cushion correction) are mounted on the yoke assembly of receivers employing cylindrical-face picture tubes.

Figure 6-9 illustrates the dual-type centering adjustments, corrector magnets, and adjustable focus taps employed by the Zenith 19L "U" Series.

a. Electrostatically Focused CRT, No Focus Control. (Refer to Fig. 6-8 for the circuit diagram of an electrostatically focused CRT, 21FP4A.) This tube has a cylindrical face to reduce the effects of glare. The focusing anode is pin No. 6, connected to a fixed 300-v source. No focus control is provided. (*Note*: In some receivers using this type of

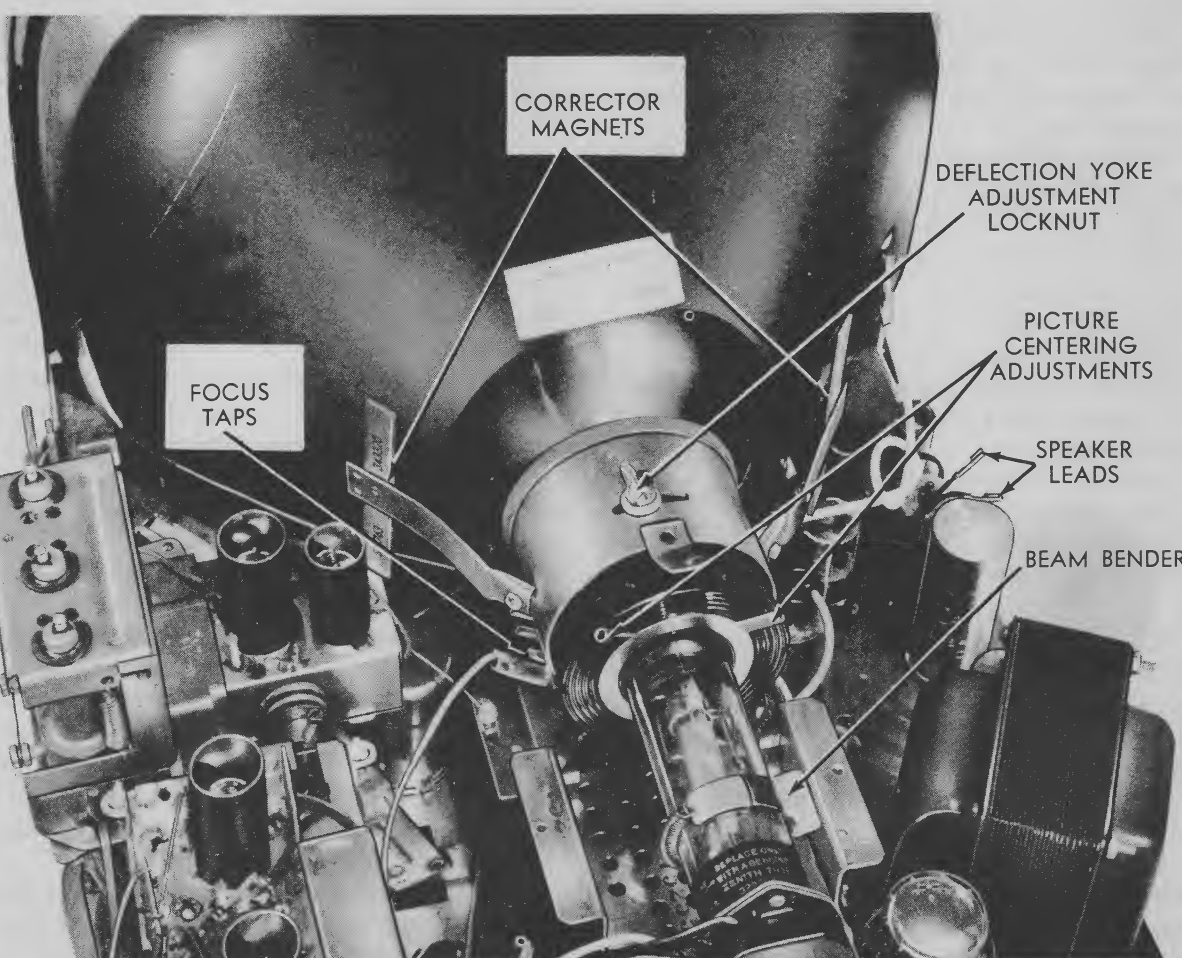


Fig. 6-9. CRT: Zenith 19L27.

picture tube, a focus control is used. However, setting of this control is not critical and good over-all focus is accomplished without it.) The high-voltage anode is operated at 15kv. The shading (brightness) control varies the d-c voltage on the cathode of the CRT from 26v to 155v. Visual cut-off for this tube varies from -33v to -77v (grid voltage with respect to cathode).

Horizontal centering is accomplished by a centering magnet. A single-field ion trap is used on this tube.

b. Electrostatically Focused CRT, with Focus Control. Figure 6-10 shows the circuit diagram of Motorola Chassis TS-292C-00. This receiver also uses an electrostatically focused CRT, 21FP4. However, a focus control, R68, is provided, which permits variation at the focusing anode from zero to boost B+ (500v). Brightness is controlled by R69, which varies cathode voltage from about 25v to 150v. The range of visual cut-off is the same for this tube as for the 21FP4A. High accelerating voltage of 16.5kv is provided.

Horizontal centering is partially accomplished by adjustment of an electronic centering control, R86. This determines the residual current flowing through the direct-coupled horizontal deflection coils. A double, magnetic, ring-centering device is also employed. This tube uses a single-magnet ion trap and correction magnets.

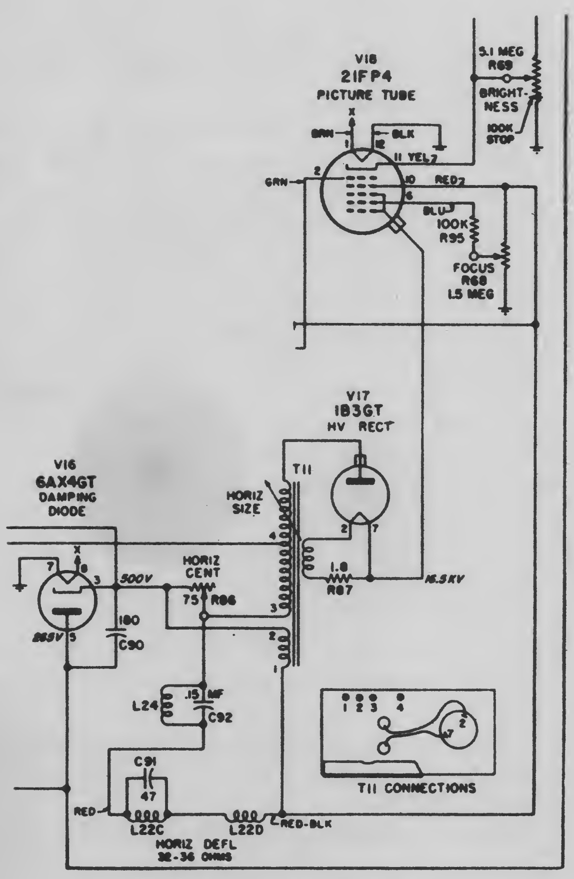


Fig. 6-10. CRT: Motorola TS-292C.

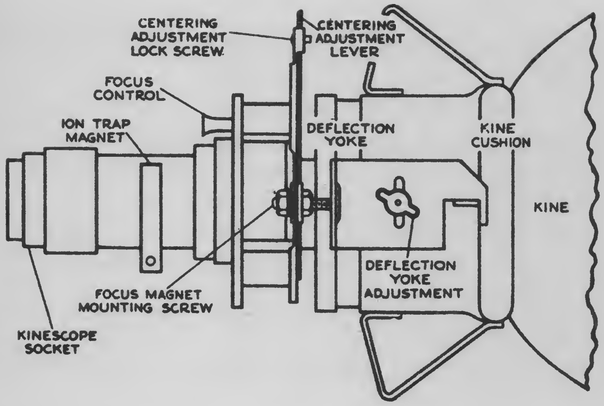


Fig. 6-11. CRT: RCA 17T301.

c. Magnetically Focused CRT. Three types of assemblies are in use for magnetically focused CRT's. These are the EM focus coil, the PM focus magnet, and the combination EM-PM device.

The EM focus coil, such as that in Admiral Model 22F2, uses an electronic focus control.

In receivers using the PM focus magnet (for example, RCA 17T301 on the 17CP4) focusing is accomplished by a mechanical control which adjusts a shunt around the magnet, thus adjusting the field around the neck of the CRT.

In receivers using the EM-PM device (GE Model 16C103) an electronic focus control is used.

d. CRT Adjustments. These are described under "II. Troubleshooting The Video Section."

e. Troubles in CRT Circuits. Troubles in this stage will affect the raster brightness, focusing, centering, and picture contrast (see Figs. 6-8 and 6-10).

(1) *No raster, sound OK* may be due to defective horizontal sweep or high-voltage sections, or to trouble in CRT circuits. This last may include:

- Defective CRT.
- Defective brightness control or associated divider circuit.
- Improper adjustment of ion trap.
- Improper adjustment of deflection and focus assembly.

(2) *Weak, flat, washed-out picture, with brightness and contrast controls at maximum* indicates a defective CRT.

(3) *No control of brightness or no brightness* indicates a defective CRT or defective brightness control circuit.

(4) *Intermittent loss of video* indicates a defective CRT or an intermittent in other stages of the video section.

(5) *Halo, out-of-focus, negative picture* indicates a gassy CRT.

(6) *Out-of-focus raster and picture* indicates defective CRT or improper adjustment of focus control, or a defective focus circuit.

(7) *Dim picture when set is first turned on,* with the picture gradually getting brighter as CRT warms up, may mean a defective CRT.

4. AGC Circuits. All present-day receivers are designed with some form of agc circuit. The purpose of agc is to maintain a relatively equal signal input to the video detector in an area of varying TV signal strength. This maintains similar contrast level as different channels are selected, without need to readjust the contrast control.

Two types of agc circuits are in actual use. These are: keyed agc and delayed agc.

Keyed (or gated-beam) agc is the most prevalent type for automatic contrast control. It was found in most of the current models of receivers checked. The others utilize delayed (or simple) agc.

a. Delayed AGC. Figure 6-12 is a circuit diagram of the agc system used in Admiral Model 19K1. V304B is one half of a 6AL5 used as the agc detector. The negative agc voltage is taken from the junction of R317 and C311 in the plate circuit of this diode. This negative voltage is then coupled as bias through a 1 K isolating resistor to the grids of the first and second i-f amplifiers, and through a 3.3 M resistor to the grid of the first r-f amplifier. The amplitude of this bias voltage depends directly on the strength of the incoming video signal. Thus, large signals give rise to a high negative bias, reducing over-all receiver gain, and vice versa.

A variable delay feature makes the agc inoperative on low-strength signals. This feature is provided by biasing the cathode of the agc detector by the setting of the contrast control, R332. For conditions of maximum signal the contrast control is adjusted for maximum bias of the video amplifier, and thus, automatically for minimum delay voltage.

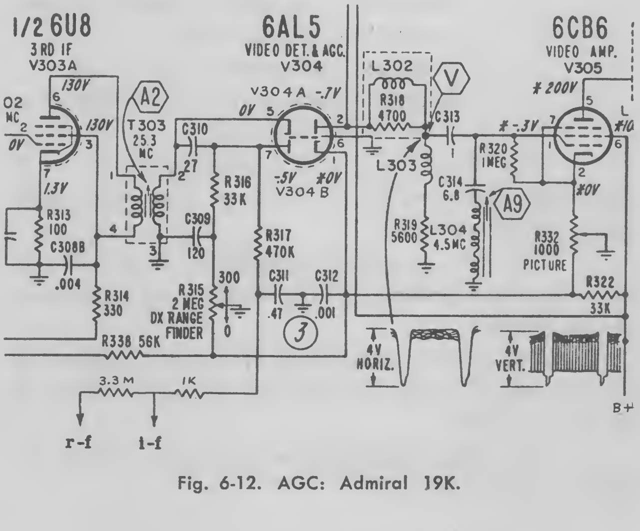


Fig. 6-12. AGC: Admiral 19K.

For minimum signal strength, the contrast control is adjusted for minimum bias of the video amplifier (hence, maximum gain) and a large delay voltage. (The maximum delay voltage possible is a little less than +3v, by divider action of R332 and R322). Thus, the delayed agc action increases receiver gain on minimum signal.

DX Rangefinder Adjustment

An additional control associated with the agc action is the DX rangefinder, R315, effective in areas of weak signal. Its setting determines the agc diode plate load resistance. The "O" position is used in areas of maximum signal and provides maximum plate load. Hence, a large negative bias voltage is developed. As the center arm is moved up R315 (toward R316), a smaller agc load is placed in the plate of V304B. A smaller bias voltage is thus developed for areas of low signal strength.

This control should be set at the "O" position, if satisfactory pictures can be obtained by using the operating controls on the front of the set.

Where the TV signal strength is weak, the picture may be improved by turning the DX control part way, or if necessary, all the way up to 300.

Snow effect can sometimes be minimized by adjustment of this control.

Caution: If the DX control is turned too far to the right (toward R316), the picture may bend (overload) on a strong signal. It is therefore important to keep this setting as low as possible, consistent with satisfactory pictures.

b. Keyed AGC. Typical of keyed agc circuits is the one found in the Magnavox 105 series (Fig. 6-13). This control circuit is a gated circuit and maintains a constant picture level despite wide variations in input signal. That is, V206 remains cut off by lack of plate voltage until the keying pulse from the horizontal output transformer arrives at the plate. At the same time, the positive sync pulse appears on the grid of V206. During this time, V206 conducts (approximately 8 percent of every 63.5-microsec interval). Since the control tube is inactive for the remaining time (92 percent), the effects of video signal and noise signal which may occur during that time interval are eliminated. The short time-constant network used in the plate circuit, where agc bias is developed, helps to reduce the random flutter typical of airplane interference. The fast-acting corrective agc voltages instantly compensate for this varying input signal.

The amount of current flowing through V206 depends on the amplitude of the keying pulse at the plate and the voltage at the control grid. The effect of the control grid depends on both the d-c voltage there and the amplitude of the positive-going sync pulse.

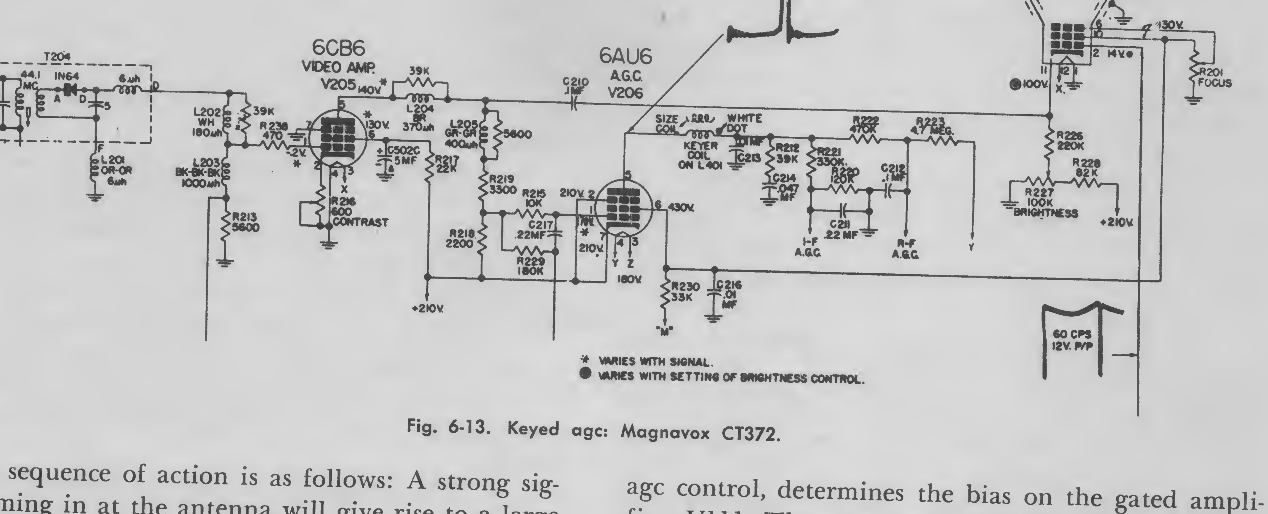


Fig. 6-13. Keyed agc: Magnavox CT372.

The sequence of action is as follows: A strong signal coming in at the antenna will give rise to a large negative-going video signal at the output of the video detector, and also a negative d-c voltage. Both the video signal and the d-c voltage are directly coupled to the control grid of V205, the video amplifier. An amplified positive-going video signal (due to 180-degree phase inversion through the tube) appears at the plate of V205. Also, the average d-c voltage at the plate rises. Both effects are directly coupled to the control grid of V206, the agc tube. As a result, when the keying pulse from the horizontal output transformer appears at the plate of V206, the tube draws more current. A higher agc voltage is thereby developed at the plate of V206. This tends to counteract the strong incoming signal by feeding a more negative bias to the grids of the controlled tubes, and thus, the gain of these stages is reduced.

When a decrease in signal strength occurs, less current flows through the agc tube, causing less negative bias voltage to be developed. This decrease in negative bias increases the receiver gain, with the result that the picture level is once again maintained.

The agc filter in the plate of V206 consists of C213, R212, C214, R221, R220, R222, C211, and C212.

The keyer coil is inductively coupled to the width coil on the horizontal output transformer and derives its excitation from it.

c. Control of AGC. Many receivers using keyed agc incorporate an agc control that determines the level of negative bias output from the gated agc circuit. Setting of this control, therefore, varies the level of negative bias applied to the grids of the agc controlled tubes.

Refer to the diagram of agc in the RCA KCS 72-72A chassis (Fig. 6-14). The setting of R149, the agc control, determines the bias on the gated amplifier, V111. Thus, the level of conduction of V111 is determined. The d-c bias voltage developed in the plate of V111 therefore depends on this control.

The proper procedure for checking the setting of this control follows:

Tune in a strong signal and sync the picture. Switch off the channel and back again. If the picture reappears immediately, the receiver is not overloading due to the setting of R149. If the picture takes a few seconds to reappear or if it bends excessively, R149 should be readjusted.

The agc control adjustment should, if possible, be made on a strong signal. If the control is set too far down on a weak signal, it may overload when a strong signal is received.

Turn brightness control all the way up (fully clockwise). Turn R149 fully counterclockwise. Disregard any slight bending of the raster. Turn R149 clockwise until there is a very slight bend or change of bend in the picture. Then turn R149 counterclockwise just enough to remove the bend or change

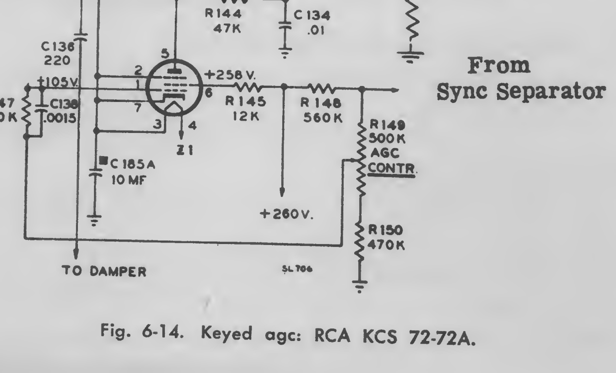


Fig. 6-14. Keyed agc: RCA KCS 72-72A.

in bend. Effectively, then, the agc control has been set on the most powerful station just below the point of overloading.

If the signal is weak, this method may not work, since it may not be possible to get the picture to bend. In that case, turn R149 clockwise until the snow in the picture becomes pronounced and then counterclockwise until the best signal-to-noise (snow) ratio is obtained.

d. Identifying Characteristics. Comparison of agc circuits has shown that the two basic types in use today are: the delayed (simple) agc, and the gated (or keyed) agc. The identifying characteristics of these follow.

(1) *Delayed agc.* Refer to Fig. 6-12. This circuit is characterized by the use of an agc detector (V304B, pins No. 1 and No. 7) to which is fed the video i-f signal. The detector is biased (positive d-c delay voltage at junction of R322 and R332 is fed to cathode, pin No. 1 of V304) so that it will not conduct on weak signals. On strong signals, a negative d-c voltage proportional to the peak of the sync pulses appears in the plate load of the detector, and after adequate filtering, is applied through an isolating and decoupling network to the grids of the controlled tubes.

(2) *Keyed, or Gated, AGC.* See Fig. 6-13. Keyed agc is distinguished by the fact that plate current of the gated amplifier (V206) is normally cut off because there is no d-c voltage applied to its plate. Only the screen grid of this circuit is B+ fed. The plate receives a positive energizing pulse from the horizontal sweep circuit (keyer coil on horizontal output transformer) at the same time that the positive sync pulses appear in its grid. Under these conditions, it conducts. The negative d-c voltage appearing in the plate load as a result of this action is proportional to the peak of the sync pulses and the d-c bias of V206. It is filtered and applied through an isolating and decoupling network to the grids of the controlled tubes.

e. Troubles in the AGC System. Troubles in this system may give rise to excessively high or excessively low negative bias voltages.

In the case of excessively high negative voltage the controlled tubes (r-f and i-f amplifiers) are either cut off or their gain reduced appreciably. Thus, both the picture and sound signal may be completely eliminated or reduced. Loss of, or weak, picture and sound may therefore be symptomatic of excessive agc bias. Strong, snowy pictures may be due to excessive bias on the r-f amplifier.

Low negative bias causes excessive gain in the r-f and i-f amplifiers, and overloading may occur. The first effects of low bias may be horizontal pulling in the picture, due to sync compression in the overloaded stage. Extreme overloading can cause a very dark picture, and finally, complete reversal of light values (negative picture) with total loss of synchronization. An overloaded negative picture caused by agc trouble may be accompanied by buzz in the sound.

(1) *Troubles causing excessive r-f and i-f gain by reducing agc bias* may result from:

Improper setting of agc control.

Weak or defective tubes, such as V206, Fig. 6-13; or defective V111, Fig. 6-14.

Open keyer coil, L401 in Fig. 6-13; open capacitor C136 in Fig. 6-14.

Shorted capacitor, C211, C212, or C213 in V206, Fig. 6-13; or shorted capacitor, C134, in Fig. 6-14.

I-F transformer leakage between primary and secondary placing a positive voltage on i-f grid, and therefore, across agc bus. This is, primarily, not an agc trouble, but gives rise to similar effects.

(2) *Troubles causing reduced r-f and i-f gain by increasing agc bias* may result from:

Improper setting of agc control.

Defective component in the circuit causing excessive current flow through the agc tube (refer to Fig. 6-14). Lower d-c voltage on the cathode of V111 due to a leaky C185A could cause this. Similarly, reduced current flow through V205 in Fig. 6-13 would increase the plate voltage of V205, increasing current through V206.

II. TROUBLESHOOTING THE VIDEO SECTION

A. Instruments Required for Servicing

The instruments required to service the video section properly are:

1. Oscilloscope with direct, low-capacitance, and demodulation probes.
2. Sweep generator covering the range of i-f frequencies.
3. Variable marker generator covering the range of i-f frequencies, preferably one with crystal check points.
4. VTVM and/or VOM.
5. Tube and CRT tester.
6. Low-impedance bias box.

B. Visual Indications of Circuit Defects

Trouble in the video section of the receiver may take on many forms, depending on the nature of the defect. However, the general classification of troubles originating in the video section are:

1. No picture, with or without sound.

2. Very dark or over-contrasty picture, accompanied by horizontal pulling or loss of sync.
3. Negative picture.
4. Weak picture.
5. Loss of picture detail.
6. Smearing of large objects.
7. Hum in picture and/or sound.
8. Troubles associated with the CRT, such as poor focus, low brightness, blank screen.
9. Inoperative contrast and/or brightness control.

C. Video Circuit Control Adjustments

Part of the troubleshooting process involves adjustment of controls affecting operation of the suspected section. This may either clear up the trouble or help isolate the defective stage. The technician must know which controls affect operation of the suspected section and must also know how to make these adjustments properly.

The adjustments affecting the video section are described below.

1. The Contrast Control. This control must be adjusted to obtain the correct picture shading. It determines the amplitude of video signal fed to the CRT. This is accomplished by changing the bias on the video output tube or by tapping off a portion of the video signal with a compensated potentiometer. In some receivers the contrast control affects the bias on the i-f and r-f tubes. When this is the case, the control must also be adjusted for minimum pulling-in of the picture and minimum buzz in the sound.

2. The Brightness Control. This is adjusted in conjunction with the contrast control to supply the correct level of light for proper viewing.

3. A Local-Distant Switch. This is used on some receivers to change the bias relationship on the i-f and r-f tubes. It may also be a simple two-position agc control. In either case, it is adjusted for the same conditions as the agc control.

4. The AGC Control. This component functions as a more refined local-distant switch, with the level of agc circuit operation adjusted for best over-all performance. In most areas, a single point on the control will suffice for all stations. When this cannot be done, some compromise will have to be made in making this adjustment. AGC adjustments are made on the strongest signal received. The station is tuned in properly and the agc control is varied. A point will be found (if the signal is strong enough) where either the picture begins to pull or a buzz is heard in the sound. The control is then backed off slightly to correct the pulling or the buzz. All the stations are then tried. This procedure is repeated on any channel showing signs of pulling or buzz.

5. Focus. Focus control is adjusted for sharpest scanning lines. This control may be electronic or mechanical.

6. Beam Bender. (or Ion Trap). The beam bender adjustment must be made quickly and properly. If improper adjustment is suspected, the position of the beam bender is rotated from side to side and shifted forward and backward on the neck of the CRT while observing the screen of CRT for the position of maximum brightness. This adjustment should be checked at normal brightness level and should be rechecked after any adjustment is made on the focus, yoke, or position of the CRT.

Initial Installation of Beam Bender. Installation may be simplified by studying the configuration of the CRT's gun structure (Fig. 6-15). Most gun structures have two main insulated supports running parallel to each other in the front-to-back horizontal plane. Where three supports are used, any pair of supports may be selected initially as the guide for orientation. The beam bender is placed on the neck of the CRT so that the magnet is located halfway between the insulated supports and between 1/8 to 1/2 in. from the CRT socket. The set is then turned on and the brightness control is advanced approximately three-fourths of the way up. After allowing sufficient warm-up time, the beam bender is quickly shifted straight forward and backward. If the screen does not light up with this procedure, the beam bender is twisted 180 degrees (halfway around) to the opposite side of the picture tube and then shifted straight forward and backward. With guns using three supports, the magnet may line up exactly on the supports or exactly in-between a pair of supports. One of these positions should light up the screen, and the final adjustment is then made at normal brightness. It is often possible to obtain two distinct positions which will light up the screen. When this is the case, the closer position to the CRT socket is the correct one. A form of neck shadow often results from the forward or incorrect position. The magnetism of the beam bender may be checked with some metallic contact, such as a steel screwdriver.

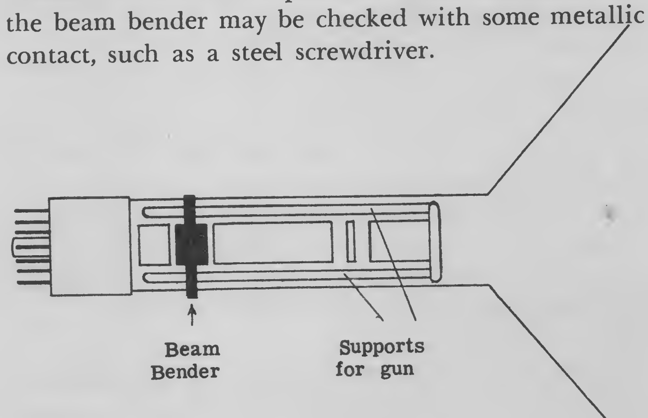


Fig. 6-15. Placement of beam bender magnet between CRT gun supports.

7. Centering the Raster

a. Double-Ring Magnet. If no pattern is available, reduce picture size so that all four edges are visible. Tune in a station. Do not center with an uncontrolled raster.

Gradually rotate the tabs with respect to each other, and rotate the centering device as a unit for vertical and horizontal centering. Recheck adjustment of ion trap after centering is completed.

b. Single Magnet Around CRT Neck. This has a positioning screw. Adjust this screw and rotate the magnet as required for proper centering.

c. Centering of Magnetically Focused Tubes. Loosen the lock screws and adjust the centering plates (which are part of the focus assembly) for proper positioning. (See Fig. 6-15.)

8. Deflection Yoke Adjustment. Loosen the lock screw on the yoke assembly. Position the yoke as far forward as possible against the flare of the tube. Rotate the yoke slowly until the picture is straight.

9. Raster Correction Magnets. Reduce raster size so that the four corners are visible. Move the magnets forward or backward until the corners become right angles and opposite sides are parallel.

D. Response Curves

1. When Alignment Should Be Checked. Checking the response of the picture i-f's and detector may become necessary in the troubleshooting process. This, however, is usually a *last* step, used when all previously tried techniques have failed to disclose the source of trouble.

2. Troubles Due to Improperly Aligned I-F's. These possible troubles may indicate improper i-f alignment:

a. Loss of picture detail.

b. Smearing of large objects.

c. Picture and sound flutter or motorboat; buzz in sound.

d. Negative picture, poor sync, caused by oscillation due to improper alignment.

e. Weak picture; no picture.

3. Procedure for Taking the Response Curve. Refer to Chapter 2 for details concerning set-up of equipment for checking response curve. In particular, observe instructions on ground connections, lead length, bias box, signal level, generator output termination, and interconnection hookups. The TV manufacturer's instructions, as outlined in the receiver service manual, should be followed as closely as possible.

In the absence of specific instructions the following procedure should be observed in taking the picture i-f and detector response.

a. Set receiver, scope, and the sweep and marker generators on a copper plate which is connected to the ground of the a-c line or to a water pipe. Ground all equipment properly.

b. Plug receiver into an isolation transformer receptacle and turn on all the equipment.

c. If receiver has separate oscillator and mixer tubes, remove or disable the oscillator (this can be done by opening plate load).

d. If receiver has a single mixer-oscillator tube, replace this with a similar dummy tube whose oscillator plate pin has been clipped.

e. If there is a test point on the chassis for feeding the grid of the mixer, couple the output of the sweep generator to this point. Otherwise, move the mixer shield off the chassis and clip the hot lead of the sweep generator to the shield and the ground lead to a common ground nearby.

f. Inject marker signal into the circuit by any of the methods previously described. Marker coupling must be loose, to prevent loading down the circuit under test.

g. Adjust the frequency controls of the marker and sweep generators for the proper i-f range. Set generator sweep width control for 8 to 10 mc.

h. Clip the direct probe of the scope vertical amplifier to the output of the video detector. Use a 50 K resistor in series with this probe.

i. To the horizontal input of the scope, connect the sweep voltage derived from the sweep generator and set the oscilloscope for external sweep operation, or use scope internal 60-cps sweep.

j. If there is a blanking feature on the sweep generator or the scope, turn it on.

k. Connect the low-impedance bias box to the agc bus, as specified by the manufacturer. Set the bias, with a VOM or VTVM, to the proper value – 3v negative if not otherwise specified.

l. Adjust the controls of all the instruments for proper operation and viewing. Set receiver contrast control as specified by the manufacturer.

m. Maintain a low sweep and marker generator output, with high scope gain for optimum conditions.

n. Observe the effect on response curve of increasing and decreasing the output of the sweep generator. The generator should be set at the point where there is no change in response curve shape as its output is increased or decreased slightly. To avoid overload, generator level should be set so that PP amplitude of response curve at output of video detector is 2 to 4v.

o. Add more ground connections between receiver and sweep generator (use braid for all ground connections). If the response curve changes, inadequate grounding exists.

p. Instrument leads should not be tied to i-f cans, tubes, or coils.

q. Observe response, and check its frequency dis-

A B

Fig. 6-16. Composite video. (A) Scope sweep at 30 cps. (B) Scope sweep at 7,875 cps.

tribution by varying marker frequency.

r. Compare this with manufacturer's specified response curves.

E. Circuit Servicing Techniques

1. The General Troubleshooting Procedure. The procedure outlined in Chapter 1 also applies to the video section and should therefore be followed here.

Since so many stages are contained in the video section, efficient servicing requires rapid isolation to one of the four subsections. Proper operation of these subsections may be determined by specific check points in the output of each. At these check points, the progress of the signal through the stages concerned is observed.

These check points are listed as follows:

a. Video Detector Output. At this point the performance of the video i-f amplifiers and video detector is checked. A normal signal (that is, a composite video signal of the proper shape and amplitude) at this point (see Fig. 6-16) means that the video i-f stages, video detector, agc circuits, and front end are operating properly, and need not be investigated. Abnormal signal or a lack of signal means that the foregoing circuits require checking.

b. Grid or Cathode of CRT. At this point the performance of the video amplifiers is checked. Assuming that a check at the video detector output gives a normal indication, the next check would be at input grid or cathode of the CRT. A normal composite video signal at this point indicates normal operation of the video amplifier(s). An abnormal signal means that the video amplifiers must be investigated.

c. Grid-to-Cathode Voltage (Bias) of CRT. Checks defects normally associated with CRT, such as dim screen, blooming, and no brightness or no control of brightness. Proper bias range, while brightness control is varied, indicates trouble with the CRT or associated circuits.

d. AGC Bus. Checks operation of agc circuits. The value of negative voltage to be expected here, with a station tuned in and everything working properly, varies; and is sometimes specified by the manufacturer. Correct voltage at this point means proper operation of agc stages and those stages feeding the signal to the agc circuits.

The following material will supplement this brief discussion of video check points, by presenting troubleshooting techniques for specific troubles.

2. No Picture, No Sound, Raster Present. Before applying any instruments to a specific circuit, the general troubleshooting procedure includes evaluating visual and sound indications to localize the defective section; inspection of suspected section for obvious troubles; adjustment of controls affecting operation of affected circuits; tube substitution in affected circuits.

If this process has not corrected the defect, it will be necessary to use test equipment.

a. Signal-Tracing, Using the Station as a Signal Source. The receiver should be tuned to an operating channel and controls adjusted for proper viewing.

(1) *Checking composite video signal.* The video detector output is the logical point at which to start. The direct or the low-capacitance probe of the scope is connected to this point (Fig. 6-1, test point 8). The fine tuner is rotated through its range to be sure a station is tuned in. Normal indication is approximately a 2-v to 6-v PP composite video signal (Fig. 6-16). When possible, the manufacturer's specifications should be referred to. This procedure uses the station as a signal source.

Proper waveform at this point indicates that all the preceding stages are operating. The scope probe is therefore shifted to the grid of the first video amplifier, then to its plate. Investigation continues at the grid of the following video amplifier (if there is one) and its plate, following the signal all the way to the picture-tube grid or cathode.

If, in this process, any point (including the input to the CRT) is reached where there is correct signal at a preceding point, but improper signal at the following point, then that circuit and the circuit in between must be investigated. Where two video tubes are used, the first video amplifier should show a gain of at least 4. The video signal for either a single- or a double-stage video amplifier should be at least 40v PP at the CRT input.

Improper waveform at the video detector test point indicates trouble in the previous i-f stages or detector or the agc circuit. The direct or low-capacitance probe is therefore shifted toward the detector proper

(Fig. 6-1, the junction of C162, Y151, and L159). If a signal is located at that point, the circuit between signal and no signal is investigated with a VTVM. Since the crystal detector is located within a detector assembly, it is difficult to check right at the detector. Therefore, after checking at the junction of L168, C166, etc., an alternate check is recommended. All the connections external to the detector assembly and making contact to L168 are removed.

(2) *Resistance check of crystal detector.* A resistance check is then made between L168 and ground. With the meter leads in one direction, a reading of 50 to 1,000 ohms is good. With the leads reversed, a reading from 25,000 ohms to infinity is good. Usual readings are 200 ohms in one direction and 100,000 ohms in the other direction. The crystal should be replaced if the ratio is less than 1 to 100. This same procedure is used when checking a crystal alone.

(3) *Checking i-f's with demodulator probe.* If the detector circuit check is good and there is still no signal, a demodulator (crystal) probe is connected to the scope and the i-f circuit investigated. Using the same procedure as before, the probe is advanced from plate to grid of preceding stages. The section within any point of discontinuity is investigated with the VOM. Signal waveforms depend on the electrical characteristics of the scope and demodulator probe combination, and are used only to indicate relative output. Often, it is possible to trace the signal up to the tuner. This, of course, depends on the particular receiver and the scope gain.

b. Signal-Tracing by Signal Substitution, Using a Sweep or Marker Generator as a Signal Source. It is possible that, in using a channel as a signal source, sufficient signal will not be present for proper indications at the tuner and the first and second i-f's, to permit use of the detector probe and scope for troubleshooting. To overcome this limitation, an alternative troubleshooting technique employing a signal generator is used.

(1) A scope with a direct probe is connected to the video detector output circuit and a modulated marker or a sweep generator set for maximum output is connected to successive grids from the last i-f grid to the mixer grid. The signal generator is set to the center of the receiver's i-f band. If a stage is operating properly, either a response curve from the sweep generator or modulation from the marker generator will appear on the scope. Moreover, the amplitude will increase as additional i-f amplifiers are thrown in. Then, any signal discontinuity is investigated with a VTVM.

(2) It is also possible to leave the generator at the mixer grid and shift the scope probe. A demodulator probe is used in the video i-f's and a direct probe, starting at the video detector, up to the CRT input.

An improperly set trap can tear out the video and/or sync information. This can readily be detected by taking an over-all i-f response curve with a sweep generator. Indications of video defects may also be due to a tuner defect, or to an agc defect.

3. Hum in the Picture and/or Sound. This condition shows that a 60- or a 120-cycle signal is entering the particular circuit affected. Occasionally, poor vertical sync may be the only indication of hum in the picture. As is frequently the case, the picture tends to sync on the hum signal instead of the vertical sync pulses.

a. Circuit Tests. These include checking tubes for heater-to-cathode leakage and scope tests on the B+ supply lines for poor filter action. It should be noted in this check that a high-gain scope will always show a certain amount of hum in the B+ supplies. When hum becomes excessive, the video or sound information passing through the particular stage will indicate hum content under a scope test. Short well-shielded scope leads and probes must be used for these checks. The signal is traced to the particular point where the hum is being introduced.

b. Sources of Hum. Some other possible sources of trouble include open grid circuits, unshielded leads, open grounds, and changes in value of filter resistors and/or capacitors.

4. Loss of Picture Detail or Smearing. Improper bandpass or ghosty reception influences the picture quality and may cause loss of detail or smearing. Ghosty reception will normally vary from channel to channel and can usually be diagnosed. Where the set itself is at fault, certain primary checks can be made. The fine-tuning shaft is shifted off the station slightly to see if a point can be reached where either greater detail or less smearing is obtained. If this is possible, alignment is the problem. However, do not confuse this test with the method of removing snow content. Snow content resulting from weak reception may be minimized by causing the video carrier to ride on a more favorable portion of the response curve than the usual 50 percent point; but this sacrifices picture detail.

a. Checks for Picture Quality To Determine Operation of I-F Amplifiers. Over-all r-f and i-f response curve checks may be required to determine exactly where the trouble lies (see paragraph D (3) of this section). In this check the manufacturer's recommendations are followed as to hookup and expected response. If the response curve is normal at the detector, then the direct probe of the scope may be shifted from the detector circuit to the following

video stages, up to the CRT input circuit. The shape of the response curve should not change materially in this check. The amplitude and phase, however, will change as the signal passes through the amplifier stages.

Improper r-f and i-f response curves may indicate a defect as well as improper alignment. An open or shorted coil or transformer will also cause symptoms of poor alignment. In addition, an unbypassed plate decoupling resistor in series with the plate load becomes part of the plate load and changes the high-frequency response of the circuit.

b. Checks to Determine Operation of Video Detector and Amplifier(s). Video detector and amplifier circuits are affected greatly by open and shorted peaking coils. These can easily be checked with an ohmmeter. Their resistance values vary from a few ohms to a hundred ohms. To check shunting resistors, one end of the coil must be opened. It is well to note, however, that these shunting resistors very rarely give any trouble.

A resistance check of a crystal detector is not conclusive and must sometimes be followed by direct substitution of a known good crystal. Polarity must be observed to avoid negative pictures and/or improper bias voltages. Open coupling or bypass capacitors can be checked with a scope or by bridging good capacitors across the suspected capacitor.

5. Servicing Procedure for AGC Trouble. If the agc circuit is suspected, some voltage checks on the agc bus may clarify the situation. For normal operation in a medium signal area, the agc voltage should be approximately –3v with respect to ground. These voltages, however, may range from –.5v to 7v. If insufficient voltages are present, the trouble may be in the agc circuit; or it may be a break in the signal path from the antenna down to the circuit which develops the agc voltage. Indications on the CRT will supply a valuable clue as to whether the trouble is overload or insufficient signal. If too much negative voltage is present, then the trouble is located in the agc circuit or is caused by the i-f amplifier oscillation.

a. The AGC Source (Output). In Fig. 6-12 junction of R317 and C311 is the logical point for a preliminary check. D-C check points in Fig. 6-13 are at the junction of C211 and R221 and at the junction of C212 and R222.

In Fig. 6-14 a bias is developed from plate of V111 to ground, and the check point is at the junction of R144 and C134. At these points the rated value of negative voltage should be found. If the voltage is excessively high or low, the preceding circuits should be investigated. If the check at the agc bus is normal, a voltage test is then made at the grid return circuits of the controlled tubes. If the source voltage is sufficient, but the bias is not reaching the i-f and/or r-f tubes, then the connecting networks must be investigated for an open or a short circuit.

Applying the voltmeter probe directly to the grid of a tuned circuit will often detune it. To overcome possible misinterpretation of voltage readings, the voltage is checked at the grid return circuits. The grid load circuit, which might be the secondary of a transformer or a grid resistor, is then checked with an ohmmeter.

The agc source supplies the agc voltage to the controlled tubes and is also dependent upon the controlled tubes for proper operation. This may create a difficult service problem if a normal volt-ohm test does not reveal the trouble. To help resolve this condition an outside low-impedance bias supply may be introduced to determine whether the trouble is in the agc circuit or in the preceding stages.

b. Low-Impedance Bias Boxes. These may be constructed simply with a battery, potentiometer, and bypass capacitor (Fig. 6-17a). A selenium rectifier or detector (crystal) may be used in place of the battery, and the exciting voltage obtained from a 6.3-v filament line (Fig. 6-17b).

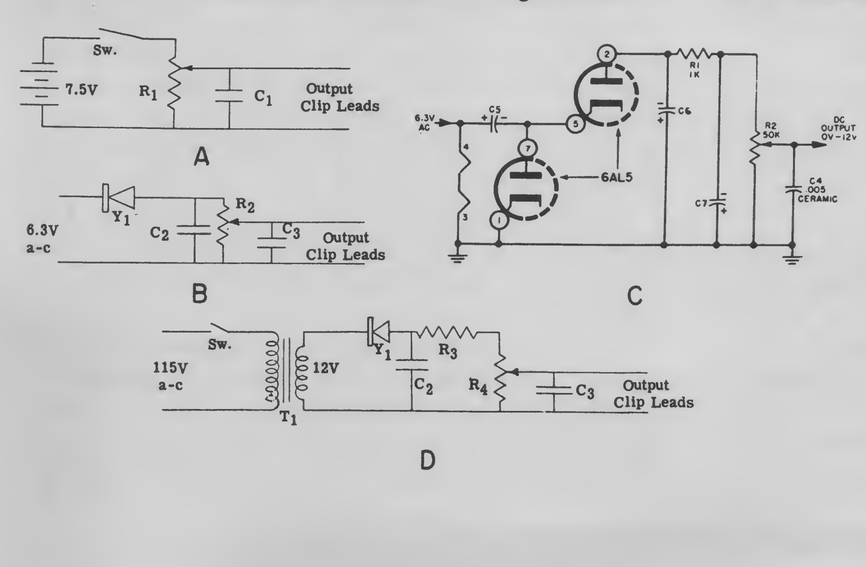


Fig. 6-17. Bias boxes. (A) Battery type; (B) rectifier type; (C) doubler type; (D) transformer type. Courtesy DuMont Service News.

R_1 = 10,000-ohm pot.
R_2 = 50,000-ohm pot.
R_3 = 500 ohms, 1 w.
R_4 = 1,500-ohm, ww pot.
C_1 = 0.1 mf.
C_2 = 5 .025 mf, 50 v.
C_3 = 25 mf., 50 v.
Y_1 = 75 ma selenium rect.
T_1 = 115 v. to 12 v. transf.

Another type is the doubler supply shown in Fig. 6-17c. For shop use, an a-c powered bias supply is suggested (Fig. 6-17d). This consists of a 115-v transformer, T1, with a 12-v secondary; a 75-ma selenium rectifier in conjunction with a filter resistor and capacitor feed; and a 1,500-ohm potentiometer. The heavily bypassed arm of the potentiometer feeds a variable negative voltage to the bias line under test. An additional 1,000-mmf r-f bypass may be placed across C3.

c. Use of the Low-Impedance Bias Box

(1) *Localizing defect to agc circuits.* When waveform, voltage, and resistance checks do not indicate the origin of the trouble, the bias box is used to localize the defect. It is connected at the agc bus to supply a negative voltage to the video i-f amplifier bias line. The bias box control is then varied to see if it is possible to bring in a good picture with the proper bias. If the control cannot help bring in a good picture, then the agc bias is not at fault. But if the control does bring in a good picture, then the agc circuit must be investigated.

(2) *Locating a gassy video i-f tube.* A gassy video i-f tube whose grid draws current after it heats up can be quickly located with the bias box. The low side of the grid return circuit of the suspected video i-f (or r-f) tube is removed from the agc line and connected to the bias box through a 1-meg resistor. The junction point of the 1-meg resistor and the low side of the grid return must remain bypassed. The set is then operated with the suspected tube receiving its proper bias from the bias box. A gassy tube will show up, after it warms up, as a voltage drop across the 1-meg resistor. This is evidenced by a decrease in voltage at the junction of the 1-meg resistor and the grid return.

d. Troubleshooting Defective AGC Circuits. When the agc circuit is at fault (as indicated by the checks made, or by visual symptoms), the bias box is connected to the agc bus and the control is set to bring in a good picture. With the video circuit thus stabilized, the agc circuit is investigated.

A typical keyed agc circuit, as illustrated in Fig. 6-13, is stabilized by connecting the bias box negative lead to the point indicated as i-f agc. The positive lead is grounded and the bias box control is adjusted for proper picture.

Scope, resistance, and voltage checks can be made with or without the stabilizing effects of the bias box. The scope is used to investigate the pulse at the plate of V206. If an improper pulse (refer to Fig. 6-13) is found at the plate of V206, a resistance check is made of the keyer coil, its primary winding L401 (the width coil), and the tap on the horizontal output transformer to which L401 is connected. One side of L401 must be unsoldered from the horizontal output transformer in order to make valid resistance checks. Next, the voltages on V206 and V205 are investigated (note that direct coupling exists from the detector through V205 and V206). This direct-coupled voltage is important to the action of the agc circuit. Therefore, the voltages on the grids in relation to their respective cathodes should be closely inspected.

Biasing the agc tube with the bias box isolated from ground, such as in Fig. 6-17d, is a further possible check when the preceding checks have failed to pinpoint a specific defective part. The bias box can be connected across the grid and cathode (negative to grid) of either V206 or V205. The VTVM is then connected to the agc line. The bias box voltage is varied to see whether the circuits are capable of developing agc voltage when the input voltage is correct. This d-c method of obtaining bias (absence of video voltage control) helps to isolate specific stages for thorough voltage-resistance checks.

e. Symptoms of AGC Troubles. Symptoms are varied, depending on the extent of the trouble. A slight reduction in agc voltage can cause one of or all the following: bending of straight objects; pulling; dark picture; snowy picture; or buzz in the sound. In an extreme case this condition can cause a negative picture or an almost completely blacked-out screen, with scrambled video information and a high buzz level in the sound. Too much agc voltage can wash out the picture slightly or completely, depending on the amount of agc voltage. (Also see paragraph D (4) of this section.)

6. Troubles in the CRT Circuit. Troubles in the CRT circuit may be due to the high-voltage circuit (already discussed), to the CRT or the beam bender, (refer also to paragraph D (5), this section) or to the low d-c voltages applied to the elements of the CRT gun. When servicing this circuit, it is important to recognize the voltage relationship which must exist between CRT elements. Using the cathode of the CRT as a reference point, the grid must be between –15v to –115v, and the first anode must be between +200v to +450v. Focus anodes (where they are used) may vary from –200v to +2,000v, depending on the type of tube used. Video information is injected at either the grid or the cathode. The unused element either is at a d-c point, with or without a retrace blanking signal (Figs. 6-8 and 6-13), or is connected to a d-c restorer circuit.

a. No Brightness or Low Brightness. If it is possible that the beam bender may have shifted its position or lost some of its magnetism, this is checked first (as described in paragraph D). The exact position of the beam bender is noted so that it may be

returned to its original position if adjustment does not help.

Voltages on the CRT gun elements are checked for relationships just discussed. It should be possible to bring the grid and cathode of the CRT to within 20 to 30v of each other. If this is not possible, a temporary jumper or a small resistor may be placed between these elements to eliminate the possibility of voltage troubles in this circuit while testing.

When direct coupling exists between the video output tube and the CRT, brightness depends partially on the plate voltage of the video output tube. The amount of current drawn by the video output tube sets the bias range of the CRT. Thus, a weak or defective tube in this circuit may cause no brightness, too much brightness, or low brightness. If all the checks mentioned are made and the trouble still exists, then the CRT itself must be checked.

b. No Control or Insufficient Control of Brightness (with or without video information). CRT elements may short or develop resistive leaks to each other, causing the video information to be lost and/or causing loss of control over the brightness circuit. This condition will occasionally show up with a resistance check. If it is necessary to make the resistance check while the tube is hot, polarity must be observed. The reason is that the CRT cathode is still emitting electrons. When the lead that is connected to the positive terminal of the ohmmeter battery is placed on an electrode closer to the CRT screen than the electrode to which the negative terminal is connected, the positive electrode will draw electrons and the meter will read. If a reading is obtained, reverse the ohmmeter leads. If a reading is still obtained, the CRT is at fault.

Circuit components may become defective (Fig. 6-8); a shorted C230, C231, or C237, or an open R228, R229 or R230, will cause insufficient control over brightness. Voltage checks (grid negative with respect to cathode) should also be made, with the CRT socket disconnected to eliminate the possibility of improper readings due to a defective CRT. In evaluating voltage checks with the CRT socket disconnected, allowance must be made for the voltage which would develop across R229 due to CRT emission current.

F. Home Servicing Techniques

1. Instruments Used — Preliminary Steps. The instruments used and the preliminary steps outlined previously are followed here. It will be helpful also to include a bias box and a detector probe for the meter. Since the preliminary steps cover most of the parts at the top of the chassis, it will be usually necessary to remove the chassis from the cabinet for more extensive testing. It is possible occasionally to check the crystal detector, the agc coil, and the CRT circuit before removing the chassis.

2. Top of Chassis Checks

a. Voltage and Resistance. Where a particular circuit is suspected, the detector may be checked for voltage output and resistance value, as outlined previously. To measure the resistance of a crystal detector, one side must be disconnected from the circuit. The agc coil can be checked for ac with a meter. A PP meter will indicate approximately the voltage listed by the manufacturer, while any other type will indicate a lower voltage. However, experience with a particular meter should supply the necessary voltage conversion factor. The agc coil may also be given a resistance check. It is necessary to open one side of the coil to obtain a true reading. The voltage on the CRT may also be checked with the receiver still in the cabinet. For these checks it may be necessary to open the CRT socket or to use needle-type test prods or an adapter plug.

b. Signal Substitution. A test capacitor lead can can be used to introduce a 60-cps a-c voltage from a filament into the video circuit. This test is used to locate a point of video discontinuity. The test can be made on either the top side of the chassis or the bottom. From above, a first video tube (if there are two video stages) may be removed and contact made between a hot filament and the plate through the capacitor lead. The capacitor lead may also be applied to the output of the video detector or the input of the CRT. The injected voltage is 18v PP and should produce a dark band on the CRT screen. The wider and darker the band, the greater the amplification.

c. Stage Elimination. Stage elimination may also be used to localize a trouble. A small capacitor (270 mmf) can be placed from grid to plate of a suspected video i-f stage. The tube may be in or out of the set (if the filament hookup permits this). This test may also be made for the video amplifier stages, using either the 270-mmf or a larger capacitor. A negative picture will result in the video amplifiers.

It may not be possible to operate the receiver out of the cabinet in the customer's home unless the technician has the necessary extension cables. The above checks are therefore recommended only for localizing the trouble. Once the chassis is removed from the cabinet, visual inspection is made and ohmmeter readings are taken. If possible, voltmeter readings are also taken in the circuit affected.

3. Checks with Chassis Removed from Cabinet

a. Demodulator (Detector or R-F) Probe. The detector probe constitutes a valuable tool for finding troubles in the stages preceding the detector. Depending on the sensitivity of the meter used, the probe may give indications from the first video i-f up to

the second detector input. Where the sensitivity of the meter becomes a limiting factor, it is possible to use the video stages as an indicator. The output of a detector probe (preferably one wired to give a negative output) is tied into the grid of the first video amplifier tube. The indications on the CRT will be weak and the agc or sync may be upset, but signal discontinuity may thus be located by checking with the detector probe at the plates and grids of the video i-f tubes.

b. Bias Box. The bias box may be used to stabilize the agc while making checks of the agc circuit. It should be noted that some of the checks listed in paragraphs A to E of this section may also be applied in the home.

G. Preventive Maintenance and Parts Replacement

1. Testing Video Tubes. Upon completion of repair, additional (or preventive) maintenance may be indicated. An obvious situation is one where the picture appears to be washed out or lacks the contrast it had when the receiver was new. This decrease in sensitivity may be due to defective video section tubes. These tubes should be tested and weak tubes replaced.

2. Sensitivity Test. Many service shops check the sensitivity of each receiver after completing a repair in the video section. One way to do this is by feeding the antenna signal into a calibrated step attenuator and coupling the output into the receiver terminals. The receiver contrast control is set for normal operation. The maximum attenuation is thrown in, consistent with a good contrast, snow-free picture. This is then compared with the attenuation required on a new or good receiver of the same model.

3. Response Curve. If the sensitivity test indicates decreased sensitivity and tube testing has not cleared this up, a response curve is taken. The overall and i-f response is checked, using a sweep and a marker generator. If the response differs appreciably from the manufacturer's rated curves, additional servicing is indicated to correct this condition.

It should be noted that the response of the receiver can be checked on a test pattern signal, if one is being broadcast. Both frequency response and sensitivity may be determined. For the sensitivity test, a scope is used at the output of the video detector, to measure the PP amplitude of the video signal.

4. Other Preventive Checks. The tests indicated for preventive maintenance in sweep and sync section servicing apply here also. In addition, the following is suggested:

a. Loose CRT bases should be cemented or taped.

b. AGC control should be properly set in the home.

c. The lead carrying the video signal to the CRT should be dressed, away from the yoke leads and from other sources of stray pick-up or increased capacitance.

d. Adjustment of i-f coils and traps should not be attempted at random. Moreover, no alignment should be tried unless the need for it is clearly indicated. Alignment is left to the last in the troubleshooting process of the video section.

e. Soldering and unsoldering of crystals should be done quickly. Moreover, the heat of the iron should be conducted away from the crystal by placing a pliers between the point being soldered and the crystal body.

5. Parts Replacement. For parts replacement, refer to previous discussions on this topic. Specific components, such as crystals, CRT's, i-f coils, transformers, and traps, should be replaced with exact replacements only, or with parts specified to be direct replacements. For CRT replacements an interchangeability chart should be consulted. Such things as physical dimensions, type of focus, and the presence and size of outer Aquadag coating should be taken into account.

CHAPTER 7. SOUND SECTION SERVICING

I. SOUND SECTION OPERATION

A. Introduction

1. FUNCTION. In the sound section the frequency-modulated sound i-f is amplified and demodulated. The resultant audio signal is amplified and activates the loudspeaker.

2. COMPONENT STAGES IN SOUND SECTION. The sound section consists of:

a. The f-m i-f amplifiers and the f-m detector.

b. The audio amplifiers and speaker.

As in preceding chapters, certain information given in the discussion of circuit operation will be covered again in the troubleshooting section for the convenience of the student and for simplifying the application of operating principles.

3. INPUT AND OUTPUT SIGNAL FREQUENCIES

a. F-M I-F Amplifiers and Detector. In the intercarrier sound system, the f-m i-f amplifiers receive a 4.5-mc frequency-modulated sound carrier from the video detector or video amplifier. Therefore, they are tuned stages at 4.5 mc. This 4.5-mc signal is obtained in the video detector by using the beat frequency produced by the sound and picture i-f carriers. These carriers have a constant difference of 4.5 mc.

The f-m detector receives the amplified 4.5-mc i-f signal and detects it. In this process of detection frequency variations are changed into the audio signal. The input to the f-m detector is tuned at 4.5 mc, except in receivers using separate i-f picture and sound channels. The output is untuned.

b. Audio Amplifiers. These stages, consisting of a voltage and power amplifier, receive the audio frequency signal from the f-m detector and drive the speaker. They are untuned stages.

B. Circuit Comparisons (Latest Receiver Models)

1. GENERAL

a. F-M I-F Amplifiers. In these stages, similarity of circuitry far outweighs differences. Thus, one-third of the new receivers that were analyzed have the sound take-off in the plate of the video amplifier. These utilize one stage of sound i-f amplification, which is frequently called the *driver.*

The other receivers employ two stages of f-m i-f amplification. Here, the sound take-off is usually the output of the video detector. Obviously, the sound i-f signal is weaker at this point than in the output of the video amplifier. Hence, two stages of i-f amplification are required.

The 6AU6 is the tube most popularly used for the i-f amplifiers. The trend also is for use of the 6CB6, 6BA6, 12AT7, 6X8 pentode section, and 6U8 pentode section.

In receivers that employ two i-f's, both single- and double-tuned first stages were found.

b. F-M Detector. The ratio detector is used most frequently as the sound detector, employing almost exclusively the 6AL5 as the detector tube. Exceptions include the use of the dual diodes in the 6T8 (Stromberg-Carlson, Model No. 521 and Philco R-201).

The ratio detector time-constant (*C* x *R* combination across the output plate and cathode, used to bias the detector) varied from 27,000 to 220,000 microsec. The most popular combination was a 5-mf capacitor across two 10 K series resistors.

The Emerson 727D and Magnavox Model 105 employ a 6AL5 as a Foster-Seely discriminator.

The Zenith 19L27, Westinghouse Model H770T21, and Capehart CX-37 use the 6BN6 gated-beam tube as an f-m detector and a-f voltage amplifier.

c. Audio Amplifiers and Speaker. In all the receivers one stage of voltage amplification and one stage of power amplification were found. Single-ended output was characteristic of all the sets. PM speakers were employed in most of the receivers, with the remainder using EM's. A listing of tubes found in these stages follows:

(1) *Voltage amplifier:*

6AV6 (most popular), 6T8 (triode section), 6C4, 6AT6 (triode section), 6SQ7 (triode section), and 6SN7.

(2) *Power amplifier:*

6V6 (most popular), 6AQ5, 6K6, 6W6, 25L6, 6BK5.

2. FM I-F'S AND DETECTOR

a. Two I-F Amplifiers and Ratio Detector. Typical of receivers using two stages of i-f amplification and a ratio detector is Philco chassis R-201 (see Fig. 7-1).

L300 tuned to 4.5-mc is the sound take-off coil and it is in the output of the video detector. From here the f-m signal is coupled by C400 to the control grid of V9, a 6BA6 used as the first sound i-f amplifier. A divider network consisting of R400 and R401 places the control grid at +124v. The cathode of V9 is returned to a +126v source. Tube current through R402 places the cathode at +128v. Thus, a 4-v negative bias is maintained. Z400, a 4.5-mc double-tuned i-f transformer, couples the signal to the second i-f amplifier, V10, a 6AU6 which acts as an i-f amplifier and partial limiter (note low plate and screen voltage, grounded cathode, and grid-leak combination consisting of C405 and R404).

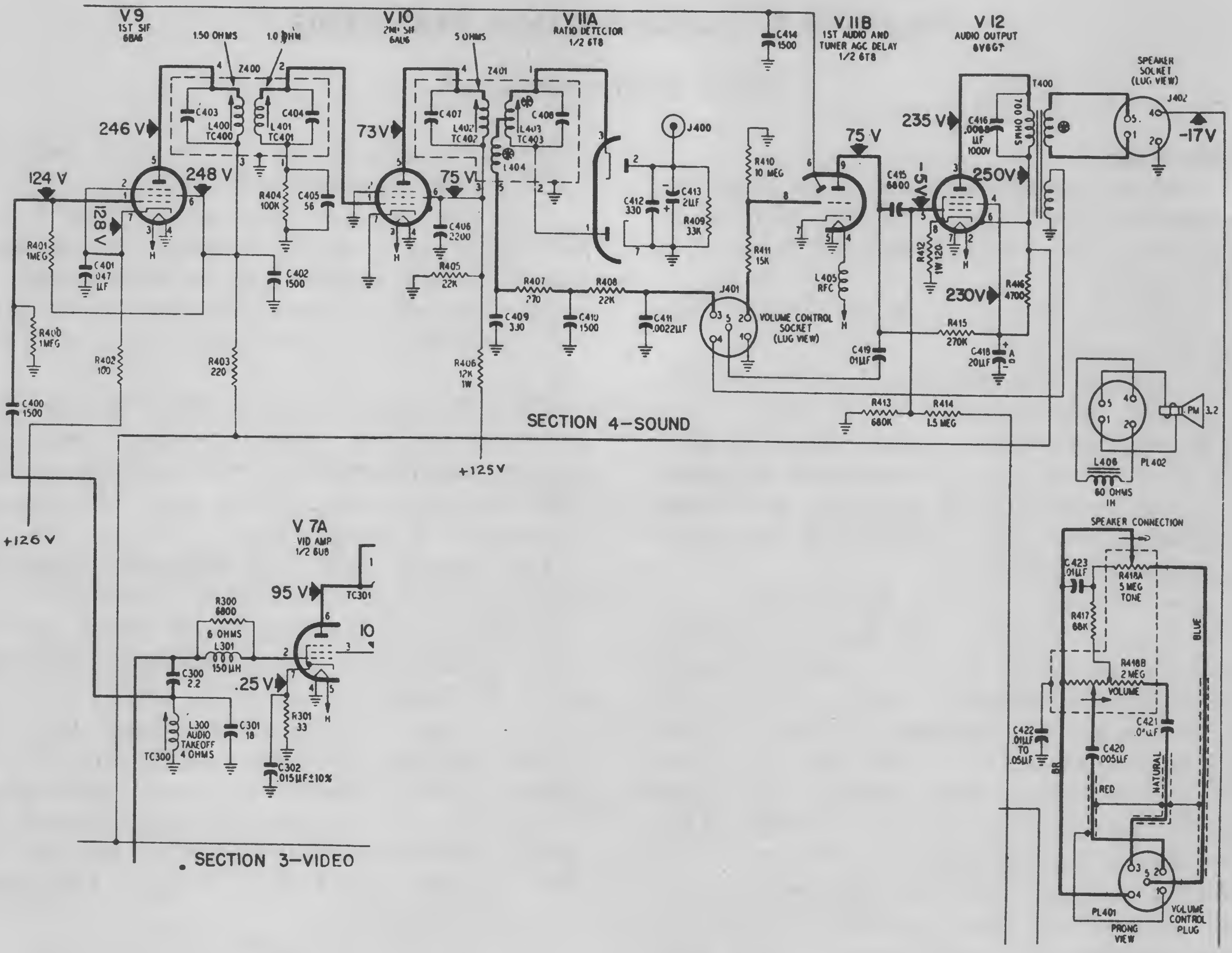


Fig. 7-1. Sound Section: Philco R-201.

Z401, the ratio-detector transformer in the plate circuit of V10, couples the f-m signal to the ratio detector, V11A (one half of a 6T8).

The circuit of the ratio detector is conventional. The combination of C413, a 2-mf capacitor, and R409, a 33 K resistor, sets the bias on the detector. The d-c voltage across this network, measured at J400 with respect to common ground, depends on the strength of the i-f signal passing through the sound circuits.

The audio output is taken from the filter network on the low end of the tertiary winding, L404 of Z401. It is delivered to the first a-f amplifier through the volume control, by way of J401 and PL401.

b. Two I-F Amplifiers and Discriminator. Figure 7-2 is the schematic diagram of the sound section found in Emerson Model 728D. Two i-f amplifiers are also used here, followed by a conventional Foster-Seely discriminator.

T5 is the sound take-off in the output of the video detector. This is slug-tuned to 4.5 mc. The f-m signal is coupled to the grid of V6, a 6AU6 tube, the first i-f amplifier. By transformer-coupling, the output of this conventional circuit is fed to V7, another 6AU6 acting as the sound limiter. The low screen voltage, +33 on the screen of V7, is determined by the divider action of R35, R36, and R34. The grounded cathode and grid leak (R32, C29) complete the identifying characteristics of this circuit.

V8, a 6AL5 tube, is a balanced discriminator, receiving its two inputs as follows:

(1) Capacitively from the plate of V7, and

(2) By discriminator transformer action (T7) from the plate of V7.

R38 and R39 constitute the full load (from cathode, pin No. 5, to ground). The audio signal is developed across this load and is coupled to the volume control, R42, and from there to V9, the first audio amplifier.

c. One I-F Amplifier and Gated-Beam Detector. Figure 7-3 shows the circuit arrangement of the sound i-f amplifier and detector used in the Zenith Super K receivers. L19, the sound take-off coil, receives its signal by transformer action from the plate of the video amplifier. This 4.5-mc f-m signal is then coupled by C35 to the grid of V7, which the manu-

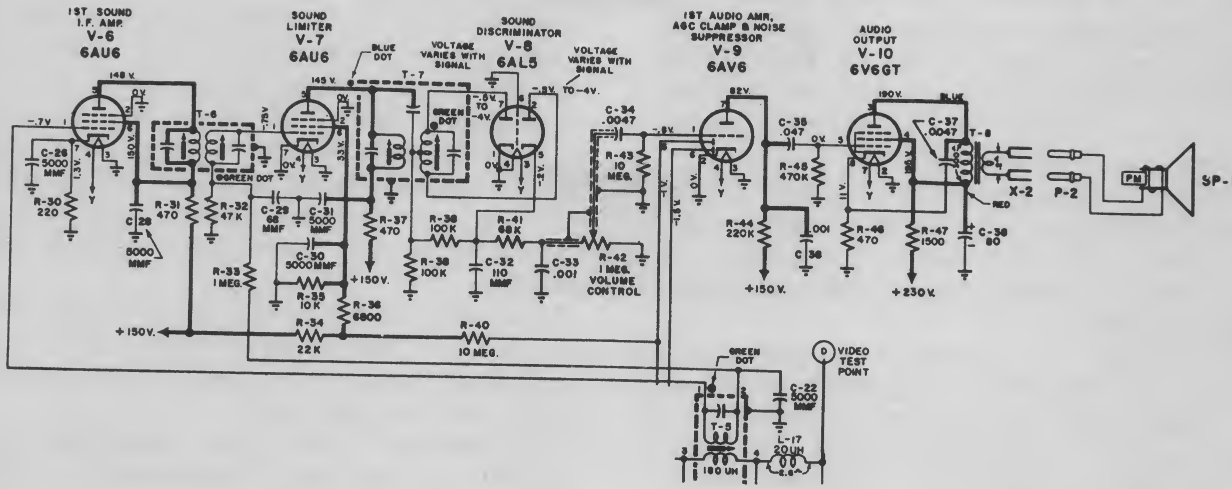
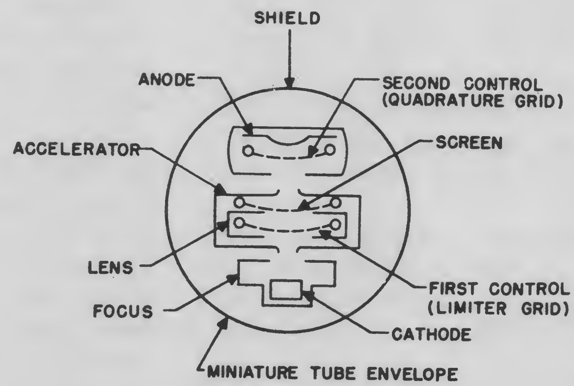


Fig. 7-2. Sound section: Emerson 728D.



ELEMENT ARRANGEMENT
6BN6 TUBE

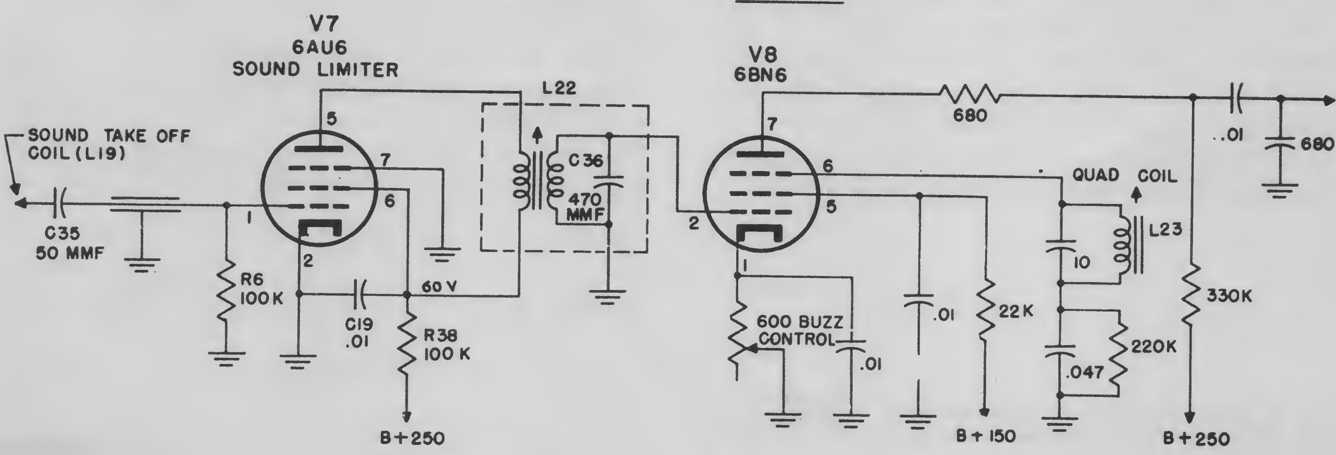


Fig. 7-3. Sound limiter and gated-beam detector: Zenith Super "K" chassis.

facturer has designated as the sound limiter. This tube is comparable in operation to the second i-f amplifiers found in Figs. 7-1 and 7-2. The grid-leak combination consists of C35 and R6. Low plate and screen voltages, coupled with a grounded cathode, are characteristic of limiter operation.

The signal in the plate of V7 is coupled by conventional transformer action to the first control grid of the 6BN6 (V8). This tube performs three functions, acting as a limiter, f-m detector, and first a-f voltage amplifier.

The operation of gated-beam detector. Figure 7-3 shows that the 6BN6 is a specially constructed tube. Limiting and demodulation characteristics are determined by its construction features. The circuit and its alignment is simplified by the fact that no discriminator transformer is required.

Electron-optics principles are used to form, shape, and accelerate the electron beam as it moves from the cathode toward the anode or plate.

The rectangular cathode is surrounded on three sides by a grounded focusing electrode. The open side of the cathode faces the positive accelerator plate, which is slotted to permit the passage of electrons toward the anode. The electrons that leave the cathode are shaped into a sheetlike beam by the focusing anode. They pass through the narrow slot in the accelerator and are projected against the limiter grid (first control).

The action of the limiter grid is equivalent to that of a gate. The gate is open (that is, the beam is permitted to pass) when the grid is slightly negative, at zero potential, or positive. The gate is closed when the grid is driven a few volts (or more) negative and the repelled electrons are collected by the accelerator electrode and returned to the cathode.

The characteristic of this grid structure is such that limiting takes place when a sine wave of more than 1v rms appears on it; that is, positive excursions greater than 1.4v PP saturate it, and negative alternations greater than 1.4v PP cut off current flow. The design of the previous amplifiers is such that, under normal operation, the amplitude of f-m i-f input to this grid is anywhere from 5v to 10v. The normal grid bias is 3v negative with respect to the cathode. Hence, limiting occurs; for despite variations in input, signal beam current intensity is fixed between the limits of saturation and cut-off. Thus, the f-m sine-wave signal that appeared at the first control grid is changed by limiter action to an f-m flat top signal after it has passed the first control grid.

When the pulsed electron beam leaves the limiter grid, it passes through the wider slot of the second accelerator, through the screen, and is projected against the quadrature grid.

The quadrature grid is also a control grid. Its effect on the electron beam is similar to that of the first grid; that is, it also will saturate anode beam current for low values of positive signal voltage and will cut off anode beam current for low values of negative signal voltages. Thus, anode beam current may be cut off by the action of either the first control grid or the quadrature grid.

The quadrature grid is connected to L23, a high Q circuit resonant at 4.5 mc. The f-m pulsed electron beam that passes by the quadrature grid induces its signal in it by space-charge coupling. When the signal frequency is 4.5 mc, the signal induced in the quadrature coil lags the original by 90 degrees. Frequencies higher than, or less than, 4.5 mc cause a phase lag greater than, or less than, 90 degrees; and the extent of phase lag is proportional to the frequency deviation. Moreover, the amplitude of the induced signal is large enough to cause anode beam current limiting in this circuit. The parallel combination of the 220 K resistor and the 0.047-mf capacitor in series with L23 constitutes the grid-leak combination for this grid.

Since the effect of the quadrature grid on anode beam current lags the effect of the control grid by either 90 degrees or by more than, or less than, 90 degrees, it can be seen that the combined effects of both grids is to cause narrower or wider pulses of

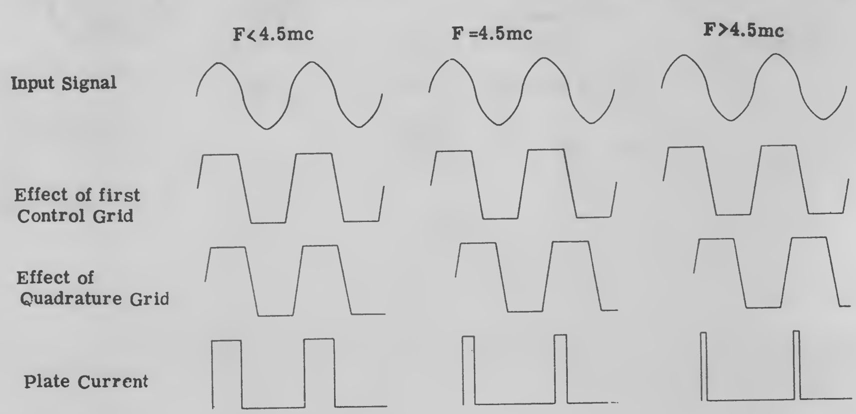


Fig. 7-4. Effects of control and quadrature grids on anode current of gated-beam detector.

current to reach the anode of the 6BN6. Figure 7-4 shows the effects of the control grid and quadrature grid on anode current at a signal frequency less than 4.5 mc, at 4.5 mc, and more than 4.5 mc.

Plate current in the 6BN6 depends on frequency deviation. There is a linear relationship between plate current and frequency deviation.

The resultant plate current pulses are integrated by the action of the 330 K plate load resistor and the 680-mmf capacitor. The integrated signal is the audio signal. F-M detection has therefore taken place. The audio signal across the volume control is of sufficient amplitude to drive the output amplifier. Hence, there is no need for an additional a-f amplifier.

It should be noted that the electrons repelled by the grids fall back on, and are received by, the accelerator. Hence, cathode current in the 6BN6 is not affected by the action of the two grids. The 500-ohm variable resistor in the cathode sets the bias on this tube. It therefore adjusts the limiting level on the first grid. It is called the *buzz control* because in actual operation it is set at a level to eliminate the effects of intercarrier buzz. The buzz is amplitude modulation by the vertical sync pulse of the 4.5-mc f-m sound carrier, and the bias range of the buzz control overcomes this when set for proper limiting action.

d. Identifying Characteristics

(1) *I-F amplifiers.* These stages generally use conventional double-tuned transformer coupling. The transformers are slug-tuned at 4.5 mc for all intercarrier sound receivers. A special discriminator or ratio detector transformer feeds the signal from the last i-f amplifier to the f-m demodulator, except where the demodulator is the gated-beam 6BN6.

(2) *Limiter.* Where two stages of i-f amplification are used, the last stage is usually operated as a combined amplifier and limiter. A limiter stage is characterized by use of low screen and plate voltages. A grid-leak combination is used to bias the tube, and the cathode is grounded. Limiters are essential before a Foster-Seely discriminator.

(3) *Foster-Seely discriminator.* This utilizes two diodes in a balanced detector circuit for f-m demodulation. The diode plates receive the signal from the center tap and secondary of the transformer. The center tap is fed capacitively from the plate of the limiter.

The discriminator full load is wired across the cathodes and the audio output is taken from the ungrounded cathode. This discriminator has a linear output *vs* frequency characteristic over the range of its operation (see Fig. 7-5).

(4) *Ratio detector.* This f-m detector also uses two diodes in a balanced circuit arrangement. The secondary of the ratio detector transformer is placed across the plate of one diode and the cathode of the other. Across the free plate and cathode of the two diodes is found the *RC* combination which biases the detector. The capacitor in this combination is usually a small electrolytic. The *R* frequently consists of two equal resistors. The center of these two resistors is used for alignment purposes. Refer to Fig. 7-1. R409 is the resistor (*R*) in the *RC* combination.

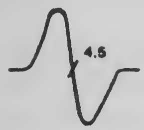


Fig. 7-5. Discriminator response curve.

The ratio detector transformer has a tertiary winding, one end of which is connected to the center tap of the secondary. The free end of the tertiary goes

TABLE V

Symptom	*Cause*
No sound, or weak or distorted sound	Defective tubes. Open or shorted sound i-f transformers or take-off coils.
Picture and raster OK	Shorted screen bypass capacitors. Open plate or screen dropping resistors. Open B+ bus. Improper alignment. Defects in audio amplifiers. Defective ratio detector capacitors. Defective i-f transformer. Fine-tuning control improperly set.
Hum in sound. Picture and raster OK	Defective tubes. Filament-to-cathode leakage in sound i-f's, detector, or audio amplifiers. Defects in audio amplifiers. Leaky filter capacitors in B+ supply, for sound section. 60-cps power line voltage coupled into audio stages. Hum bucking adjustment (where used) improperly set.
Buzz in sound. Picture and raster OK	Overload or contrast control set too high. Fine-tuning control improperly set. Improper sound i-f and discriminator alignment. Sync pulse radiation from video or sync section into audio stages. Improper lead dress. Mechanical buzz from loose laminations in transformer. Bad grounds. Improper setting of buzz control in gated-beam circuit.
Motorboating in sound. Picture and raster OK	Defects in audio section.

to an *RC* network from which the audio signal is taken.

The frequency response of the ratio detector is the same as that of the discriminator (see Fig. 7-5).

(5) *Gated-beam detector.* This is characterized by the use of a specially constructed tube, the 6BN6. A conventional i-f transformer feeds the first control grid of this tube. A high *Q* circuit tuned at 4.5 mc is wired across the quadrature grid. The audio signal is taken from the plate.

Although this tube is specially constructed, it is shown diagrammatically like any pentode. Pin No. 2 is the first control grid, and pin No. 6 is the quadrature grid.

e. Possible Troubles in these Circuits. Although there are some variations in the circuit arrangements of the sound i-f's and detector, they are similar in function. Hence, servicing problems are similar. A list of possible defects is given in the table on page 91.

3. Audio Amplifiers

a. Circuit Description. Circuit arrangement of the audio amplifiers is almost identical in all the receivers compared (see Fig. 7-2 for the audio stages in the Emerson 728D).

The output of the discriminator, V-8, appears at the junction of R41 and C32. R41 and C33 constitute the de-emphasis network. The volume control feeds this signal to the grid of the triode section of V9, the a-f amplifier. This is a high-gain tube whose output is coupled by C35 to the grid of V10, the audio output tube. The output transformer in the plate of this power amplifier couples the audio signal to the speaker.

b. Possible Defects in These Stages. Troubles in these stages will affect the volume and quality of sound. A classification of troubles follows:

(1) *No sound.* This may be due to defective tubes. open coupling capacitors, open output transformer, shorted screen bypass capacitor, open voice coil in speaker, absence of B+ due to open plate-load resistors, shorted plate bypass capacitor (C36 in Fig. 7-2).

(2) *Weak or distorted sound.* This condition may be caused by defective tubes, leaky coupling capacitors, changed-value plate-load resistors, leaky screen and plate bypass capacitors, partially shorted winding of the output transformer, or low B+.

(3) *Hum in sound.* Bad tubes; poorly filtered B+ supply; filament-to-cathode leakage in audio tubes; bad audio ground connections; unshielded, long audio leads; and improper dress of components.

(4) *Buzz in sound.* Bad ground connections, improper lead dress, and stray coupling of sync pulse into audio stages.

(5) *Motorboating.* Open ground connections in grids of a-f amplifiers, oscillation due to improper dress of critical components, and defective bypass capacitors.

II. TROUBLESHOOTING THE SOUND SECTION

A. Indications of Circuit Defects

Unlike the other TV receiver sections studied, troubles in the sound section mainly affect the sound coming from the receiver. The following troubles may occur.

1. No sound, picture and raster OK.
2. Distorted sound, picture and raster OK.
3. Weak sound, picture and raster OK.
4. Hum in sound, picture and raster OK.
5. Buzz in sound, picture and raster OK.
6. Motorboating in sound, picture and raster OK.
7. Microphonics.
8. No picture, no sound, due to defective sound tube whose cathode supplies d-c voltage to a common stage.
9. Interference in picture due to radiation from sound section.

When sound alone is affected in the performance of a TV receiver, it is a clear indication to the technician that the trouble must be sought in this section. If both sound and picture and/or raster are affected, circuits common to sight and sound must be investigated.

sound, or hum or buzz in the sound may all result from improper alignment. However, as in the case

1. VTVM and/or VOM.
2. Sweep and marker generators.
3. Oscilloscope.
4. Tube tester, capacity tester.

C. Response Curves

1. Troubles Due to Improperly Aligned Sound I-F Stages. Complete loss of sound, weak or distorted curve.

of the video i-f amplifiers, realignment should not be undertaken except as a last resort, when all other tests have been tried. Then, before realignmnt is attempted, the response curve of the sound i-f's and f-m detector should be checked.

These characteristics can be determined in observing the response of the sound i-f's:

a. Shape and frequency distribution of the

b. Sensitivity of these stages. The amplitude

B. Instruments Required to Service Sound Section

The following test instruments are needed to service the sound section properly.

of the response curve can be compared with results

obtained in checking a normally operating receiver.

2. Procedure for Taking the Response Curve. The manufacturer's instructions, as outlined in the receiver service manual, should be followed as closely as possible. Previously outlined instructions for ground connections, lead length, etc. should be observed.

In the absence of specific instructions the following procedure should be observed in taking the response of the f-m i-f's and detector in intercarrier sound receivers.

An unmodulated signal generator set accurately at 4.5 mc, a TV channel on the air, or a sweep frequency generator may be used as the signal source.

a. Using 4.5-mc Unmodulated Signal

(1) Short out the control grid of the third or fourth pix i-f amplifier.

(2) Maintain low generator output.

(3) Connect generator through 0.01-mf capacitor to output plate of video detector (or to cathode if the cathode element is used as the output).

(4) Zero-center VTVM and, in the case of a ratio detector, place hot lead at bottom of tertiary winding and ground lead to midpoint of *RC* filter network in the ratio detector.

Note: In many ratio detector circuits the resistance in parallel with the *C* in this circuit consists of two equal series resistors. The midpoint is the junction of these two resistors. If only one resistor is used (for example, R409 in Fig. 7-1), it will be necessary to parallel this with two 100 K matched series resistors. The junction of these two resistors is now the midpoint to which the negative lead of the VTVM is connected.

(5) If a Foster-Seeley discriminator is used, hot lead of zero center VTVM is placed across full load (pin No. 5 in Fig. 7-2) and negative lead to common ground.

(6) Vary signal generator 100kc on either side of 4.5-mc. VTVM should deflect equal amounts on either side of zero. If it does not, the alignment of these stages must be investigated.

(7) Remove short from grid of pix i-f amplifier.

(8) Remove the two series resistors which were placed across *RC* network in ratio detector.

b. Using Transmitted TV Air Signal

(1) Connect antenna.

(2) Tune receiver to an operating channel. Pad if signal is excessively strong.

(3) Adjust fine-tuning control for proper picture.

(4) Follow steps (4) and (5) above.

(5) Vary adjustment of the secondary of the sound detector transformer slightly on either side of its setting. VTVM should deflect equal (approximate) amounts on either side of zero. If it does not, the alignment of these stages must be investigated.

(6) Follow steps (7) and (8) outlined above.

c. Using Sweep Frequency Generator

(1) Follow the first four steps as outlined in procedure for taking video i-f response (see Chapter 6).

(2) Couple the output of the sweep generator through a 0.01-mf capacitor to the output of the video detector. This will be the plate in most instances. Occasionally, the cathode is used as the output.

(3) Inject marker signal into the circuit, as previously instructed. Marker should be calibrated at 4.5 mc.

(4) Adjust generator sweep frequency and width controls so that it is sweeping 100kc on either side of 4.5 mc.

(5) Set up the scope for proper viewing, using sweep voltage derived from the f-m generator. Blanking, if available, should be used.

(6) The scope direct probe, in series with a 50 K resistor, should be connected to the top of the volume control. Low side of scope should go to chassis ground.

(7) Adjust controls of all instruments for proper viewing. It may be necessary to vary the frequency of the sweep generator to locate the response curve. Turn volume control all the way down, or keep volume at low level.

(8) Maintain a low sweep and marker generator output, with high scope gain. Test for overloading by varying output of sweep generator.

(9) If the circuits are properly peaked, the familiar f-m detector response will be seen (Fig. 7-5).

(10) Vary the marker generator on either side of 4.5 mc. A pip will be seen on the curve on either side of 4.5 mc. It should disappear at 4.5 mc if the alignment has been properly carried out.

D. General Troubleshooting Procedure

Here, as in other sections of the receiver, preliminary checks are made to isolate the defect before resorting to instruments.

1. Isolating Defect to Sound Section. Specifically, to isolate the defect to the sound section, the technician will note whether a trouble affecting sound also affects the video information. If it does not, and if the raster is not affected, then the sound section is the most likely source of trouble.

2. Other Preliminary Steps. The next steps include visual inspection of the sound section; manipu-

lation of the volume control and, in the case of the gated-beam detector, adjustment also of the bias (buzz) control; replacement, one at a time, of the tubes in this section with known good tubes.

If these tests do not clear up the trouble, an organized, logical troubleshooting procedure should be followed, using test instruments. The actual steps involved will be determined by the nature of the trouble.

The approach to specific types of troubles will be discussed in subsequent paragraphs.

3. NO SOUND, PICTURE AND RASTER OK. This trouble may be due to defects in the sound i-f's, f-m detector, and a-f amplifiers. It is possible to choose a midpoint in these stages and eliminate the good stages with one test.

a. Sound Check Point. A logical point is the input to the audio amplifiers. The technician can place his finger on the top of the volume control, with volume all the way up, or connect 6.3v a-c filament voltage through a 0.01-mf capacitor to this point. A loud 60-cps hum will be heard if the amplifiers are operating properly.

If a hum is heard we can presume that the amplifiers are good. We therefore seek the discontinuity in the signal path in the f-m detector and sound i-f amplifiers. If nothing is heard, our trouble is in the audio amplifiers and these should be checked.

b. Servicing the I-F Amplifiers and F-M Detector

(1) *By signal substitution, using a sweep generator as a signal source.* If trouble is indicated in these stages, it is possible to localize the trouble rapidly by injecting a 4.5-mc f-m signal from a sweep generator into each of the stages from the f-m detector back to the point of sound take-off. If the stage is operating properly, a 60-cps hum or buzz will be heard in the speaker. The stage that does not permit the signal through is then investigated with a VTVM or VOM.

Following this procedure in Fig. 7-2, the generator would be connected first to pin No. 1 of V7, and then to pin No. 1 of V6. If a signal goes through these stages, but off frequency, a response check of the entire sound i-f's and detector would then be made, using the sweep and marker generators and scope as an indicator. Both frequency response and gain should be observed.

(2) *By signal-tracing, using a demodulation probe and channel signal.* Another method involves use of a demodulation probe. This is connected to the vertical input of the scope, with the scope vertical amplifier adjusted for maximum sensitivity. An operating channel is selected and the fine-tuning control adjusted for proper picture. The progress of the f-m signal from the sound take-off point through the sound i-f's is traced. The audio signal will be very weak closest to the take-off point, but will get stronger (larger) as it proceeds toward the f-m detector. Any discontinuity will isolate the trouble to a specific stage, which is then checked with a meter.

Specifically, in Fig. 7-2 the demodulation probe would be connected successively to pin No. 1 of V6, pin No. 1 of V7, and Pin No. 7 of V8. If the stages oscillate, use an isolating resistor whose value is 5 K to 50 K in series with the probe.

c. Servicing the Audio Amplifiers. Referring to Fig. 7-2, V9 and V10 are typical audio stages. If filament voltage applied to the top of the volume control is not heard in the speaker, the filament signal is next applied to the grid, pin No. 1 of V9. If sound is now heard, the trouble may be due to a defective volume control, R42; a shorted capacitor, C33; or an open coupling capacitor, C34.

If no sound is heard with the signal on the grid of V9, our signal is shifted to the control grid, pin No. 5 of V10. If we now hear the 60-cps hum, our trouble lies in V9. Otherwise, our trouble is in the circuit of V10. In either case, a VTVM or VOM is next used to isolate the defective component. D-C voltage checks are made at the plate, screen, grid, and cathode of the suspected stage. If this does not give the answer, filament voltage is checked and resistance checks are made of components in the stage. Suspected open coupling capacitors (C34, C35) may be bridged with known good capacitors. Suspected shorted capacitors (C36, C37, C38) may be opened and the effect noted. The primary of T8 may be checked for continuity in the circuit. However, the secondary of T8 or the voice coil of the speaker must be checked independently, with plug P2 out.

4. WEAK OR DISTORTED SOUND, PICTURE AND RASTER OK. With some modifications, the procedure used for localizing a sound discontinuity is used in locating the source of weak or distorted sound.

a. Checking Weak or Distorted Audio Amplifiers. If it is suspected that the trouble stems from the audio amplifiers, these may be checked readily with an audio oscillator (or other available audio signal), including 60-cps filament voltage and scope.

A .5-v PP audio (sine-wave) signal is injected into the top of the volume control. The volume control is set halfway up. The progress of the signal is then followed with a scope. As the scope probe is moved progressively from grid to plate of the voltage and power amplifiers, a voltage gain should be observed. Moreover, the signal should remain a pure sine wave. If clipping or limiting is observed (that is, sine wave appears squared off at top or bottom, or is otherwise distorted), the volume control is turned slightly down

to eliminate the possibility that the amplifiers are being overloaded. If limiting is still observed, the stage causing the trouble is checked with a VTVM.

Similarly, a stage showing no gain, or very little gain, must also be checked with a VTVM.

b. Checking F-M I-F Amplifiers and Detectors. Checking the response curve of these stages should lead to the source of trouble. The technician is particularly interested in gain and response characteristics.

5. HUM IN SOUND, PICTURE AND RASTER OK. Hum may be introduced in the audio amplifier stages by poor shielding, improper dress, poor B+ filtering, or defective components. Or hum may be modulation of the f-m carrier, introduced between the sound take-off and the output of the sound detector. Improper alignment of the f-m detector secondary may cause hum; and hum may be tunable, caused by defects in the front end, which may or may not affect the picture. Hum may also be caused by filament to cathode leakage in the sound i-f's and is evident only when a channel is tuned in. Therefore, it is obviously necessary to determine which stages are causing this trouble.

A simple test to isolate hum to the audio amplifier is to tune the receiver off-channel. If hum is still heard, the trouble is in the audio stages or B+ supply. If turning the volume control down gradually reduces the loudness of hum gradually, it is being introduced prior to the volume control. If there is no effect, the trouble is after the volume control. In the latter case it is possible to isolate the trouble further by shorting out the grid of the first audio amplifier. If this does not affect hum, then the the picture. Hum may also be caused by filament-to-cathode leakage in the sound i-f's and is evident trouble must be sought following the input point. *Note*: A defect in this first audio tube may not be indicated by this check. Probing the affected audio amplifier with an oscilloscope will readily uncover the trouble.

If the trouble lies in the circuits preceding the audio stages, it is necessary to determine whether it comes in prior to the sound take-off point or in the subsequent f-m i-f amplifiers. The shielded scope probe is connected to the output of the video detector. If the composite video signal is seen to contain an abnormal hum signal, it is an indication that hum is being introduced in the front end or the video section. Otherwise, the defect is in the f-m i-f amplifiers or the detector.

6. BUZZ IN SOUND, PICTURE AND RASTER OK

a. Buzz is more prevalent in intercarrier receivers than in sets employing separate sound and picture channels (split-sound receivers). Possible causes for buzz in intercarrier sets are:

(1) *Overmodulation of the video carrier at the transmitting station.* This can be checked by switching from channel to channel. If buzz is heard on one channel only, regardless of setting of the contrast and fine-tuning controls, then the trouble normally can be traced to the transmitter or the alignment of the receiver local oscillator for that channel. However, a very strong channel, though not overmodulated, may cause buzz if the agc circuits of the receiver cannot handle this signal adequately.

(2) *Improper alignment of the secondary of the f-m detector.* A response curve will reveal this source of trouble. A 4.5-mc crystal or a crystal-calibrated 4.5-mc marker should be used. If response curve is incorrect, the secondary circuit should be retuned. Then tune in a channel and readjust secondary, if necessary, for minimum buzz.

(3) *Improper alignment of the sound I-F and limiter stages.*

(4) *Improper video i-f alignment.* Normally, the sound i-f carrier should be about 5 percent up on the curve. Checking the over-all r-f i-f response curve at the output of the video detector will reveal whether the sound carrier is up too high. In Fig. 6-5 the f-m i-f carrier (41.25 mc) is properly placed. This curve or the manufacturer's guide may be used for reference.

Note: Before realignment is attempted in steps (2) through (4), the technician should check tubes in the affected section, since improper gain will change curve response and lead to buzz.

(5) *Open C in ratio detector.* In the case of receivers with a ratio detector, the large capacitor in the *RC* combination determines the limiting level; if open or defective, it will introduce buzz. The capacitor referred to is C413 in Fig. 7-1.

(6) *Improper setting of fine-tuning controls.* The fine-tuning, agc, or buzz controls (in gated-beam detectors) will cause this condition. These should be varied to note effect on buzz level.

(7) *Leakage from vertical sweep or sync stages into audio amplifiers.* This can be checked by temporarily shorting out vertical oscillator and input of sync circuits and noting effect.

(8) *High-voltage arcing.* This may be mistaken for buzz. This can be checked by temporarily disabling the horizontal oscillator. If buzz disappears, the trouble is associated with the high-voltage or horizontal sweep sections.

(9) *Loose laminations.* These may be found on the vertical oscillator transformer, vertical output transformer, or power transformer.

(10) *Ungrounded shield or screen used for ventilation.* This shield is usually located on shelf

below receiver.

b. Procedure to Isolate Source of Buzz. A logical procedure to isolate the cause of buzz follows:

(1) Adjust fine-tuning, contrast, buzz, and agc controls to determine whether defect is eliminated. If it is, no further checks are required. Otherwise, continue testing.

(2) Test tubes in sound i-f amplifiers and detector; replace defective or weak tubes.

(3) Test tubes in video section and replace weak or defective tubes.

(4) If ratio detector is used, check capacitor, C413 (see Fig. 7-1).

(5) Short out sync input, and note effects.

(6) Disable horizontal and vertical oscillators, in turn, to eliminate possibility of arcing, loose transformer laminations, or other leakage.

(7) Observe f-m i-f response curve and readjust if necessary.

(8) Observe video i-f response curve and readjust the trap or coil that determines the level of sound i-f carrier (if this is necessary).

7. Motorboating, Picture and Raster OK. This trouble may be due to an open output filter or decoupling capacitor in the audio amplifier B+ supply, or an open grid resistor in the audio or power amplifiers (Fig. 7-2, R43 and R45).

A simple procedure is to bridge the suspected capacitor with a known good one and to make a resistance test (on high range) of the grid resistors of the audio amplifiers.

E. Home Servicing Techniques

All checks outlined in paragraph D may be made in the home, except for those requiring use of the sweep generator and other equipment which the technician may not have with him.

F. Preventive Maintenance and Replacement Parts

The simplest preventive maintenance check is, of course, careful testing of all tubes. If weak tubes are found, they should be replaced. This applies also to other components in the sound system that may be suspected or which are tested and found to be at less than their rated efficiency.

All replacement parts require matching with the original parts. Substitute tubes, resistors, etc. should be used only when proved to be efficient in the circuit where they are used.

CHAPTER 8. LOW-VOLTAGE POWER SUPPLY SERVICING

I. OPERATING PRINCIPLES OF THE SECTION

A. Introduction

1. Function. The low-voltage power supply section of a TV receiver converts the line voltage to the required filament, screen, and plate voltages necessary for receiver operation.

2. Components of the Power Supply. Two types of low-voltage supplies are used. Each uses different means of converting the a-c line voltage to d-c.

a. The two types are:

(1) A power transformer, vacuum-tube rectifier (s), and filter and d-c divider networks.

(2) A selenium-rectifier (transformerless) power supply and filter, and voltage divider networks, plus either a filament transformer or a series filament hookup, or a combination of both.

b. Input and output voltages are:

(1) The transformer-type a-c TV receiver power supply; this converts the line voltage (usually 117-v 60-cycle) to dc by full-wave rectification after the transformer has stepped up the line voltage. The selenium-type (transformerless) supply uses the line voltage directly and converts the ac to dc by half-wave rectification with voltage-doubler action.

(2) The receiver tubes receive their filament power either from an appropriate winding on a power transformer or by a series arrangement directly off the a-c line.

B. Circuit Comparison (Latest Receiver Models)

1. General. All the receivers analyzed were a-c powered and used either 17-in., 20-in., or 21-in. picture tubes.

a. Power transformers which supply full-wave vacuum-tube rectifiers and parallel filament arrangements were found in two-thirds of the sets. In this group one-half used a single vacuum-tube rectifier, and the remainder used two rectifier tubes. Two of these receivers used the individual tubes as half-wave rectifiers, the combination comprising a full-wave rectifier.

b. The remaining one-third of the receivers were found to contain transformerless circuits using two selenium rectifiers in a half-wave voltage-doubling circiut. Half of this group supply power to the filaments by means of a filament transformer. Only one set supplied all the filaments in a series-parallel arrangement directly from the line. The remaining sets used a combination of filament transformer and series arrangement. In one case a filament transformer supplied all the filaments requiring more than 0.3 amp, plus the front-end tubes. The remaining tubes were supplied by a series 0.3-amp line. In another case, all the 6.3-v tubes were supplied by a transformer, and a series arrangement supplied the remaining tubes.

c. The rated power consumption varied from 130w to 275w. This maximum and minimum wattage rating was found in two makes of receivers, both using 17-in. picture tubes. In general, the picture-tube size did not influence the comparative wattage ratings. The average value of power consumption was 200w.

d. An ungrounded filament winding was provided in 30 percent of the receivers to supply the 6W4 damper tube. Only one receiver employed the common filament line (one side grounded) to supply the 6W4 damper tube. The remaining sets used damper tubes (such as the 6AX4, 12AX4, 6V3, or 6AS4) which could receive filament power from any normal source, due to higher rating of breakdown voltage between filament and cathode.

e. The audio output tube was used by 20 percent of the receivers in a voltage-divider regulator circuit to supply the lower B+ voltage for the usual 135-v line. Twenty-five percent used a series arrangement of two tubes to supply lower B+ values to the individual tubes. This was in addition to the conventional front-end cascode arrangement.

2. Description

a. Transformer Power Supply. The conventional power supply uses a power transformer to supply both the filament and the B+ voltages. The power supply used in the Emerson 727D is illustrated in Fig. 8-1. The transformer automatically isolates the line voltage from the remainder of the receiver. The filament winding is a center-tapped 12.6-v winding. One half of this supplies one string of 6.3-v filaments; and the other half, another string of filaments. A separate isolated winding, W-W, supplies filament power to the 6W4 damper tube and is tied into the horizontal output circuit at a high a-c and d-c potential. The B— contains a 0.5-amp protective fuse that will open the B supply in case of excessive B+ drain. An unbypassed 8.5-ohm resistor (R49) supplies a negative bias for the video amplifier. The two rectifier tubes, V20 and V21, are each connected as half-wave rectifiers to make up a full-wave circuit. In case of failure of one tube, the circuit becomes a half-wave circuit. The output voltage on the +230-v line then decreases about 12 percent, with a small increase in ripple. The ripple at the +245-v line, however, increases 100 percent. Since this receiver incorporates additional filtering previous to the use

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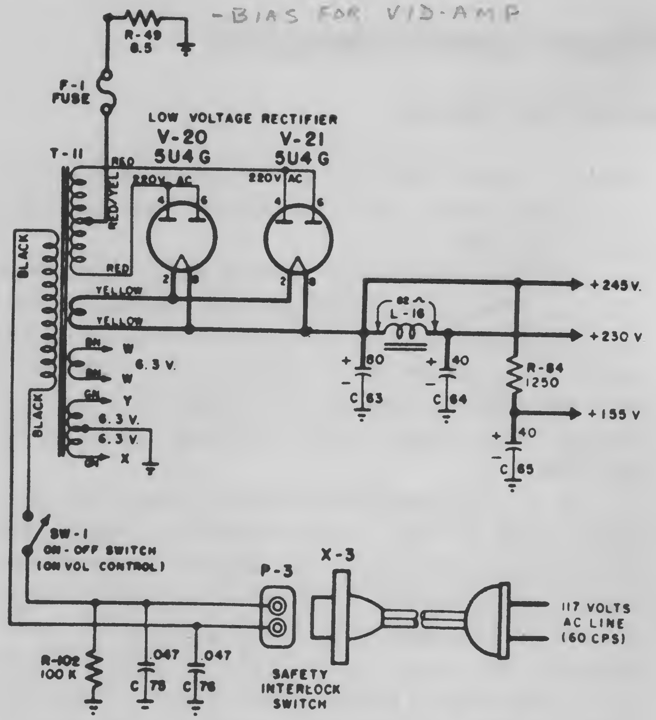


Fig. 8-1. Low-voltage supply: Emerson 727D.

of this line, the additional ripple is of no consequence.

b. Selenium Rectifier Power Supply (Transformerless). The selenium-rectifier supply has recently become popular with receiver manufacturers. This circuit, as illustrated by the GE 21T1 (Fig. 8-2), uses two selenium rectifiers in a half-wave voltage-doubler circuit. The power transformer windings necessary for the vacuum-tube rectifier (s) and the rectifier tube (s) are eliminated. The disadvantage of having the power line connected directly to chassis is overcome by using only part of the chassis structure for the B— and connecting the front and rear apron of the chassis as shown in Fig. 8-2.

The voltage-doubler circuit includes a 4.6-ohm limiting resistor, R401, which limits the initial surge current through the uncharged 300-mf capacitor, C401. On the negative half-cycle, C401 charges up through X401, a selenium rectifier. The charge developed on the capacitor has the polarity shown and is equal to approximately 130v. On the positive half-cycle, the line voltage adds to the charged capacitor and current flows through X402, the second selenium, and charges capacitor, C402, to approximately 260v. At this point the B+ is further filtered by L401 and C403A. It should be noted that more filtering is required in this type of circuit, due to the 60-cycle ripple this voltage contains (instead of the usual 120-cycle ripple obtained from a full-wave rectifier).

The Sloblow 1.6-amp fuse, F401, is capable of handling the initial surges of this circuit while maintaining adequate protection.

The Globar resistor, R402, in series with the series filament string, protects these filaments against initial surges. It is composed of a material that changes in resistance value according to the amount of current that flows through it. Thus, its resistance cold may be 10 or 20 times larger than its operating resistance, which in this case is 31 ohms. Therefore, when the receiver is first turned on, the voltage across the individual filaments is small until the Globar gradually heats up and reaches its operating value. This action is opposite to that of a filament which has a low resistance when cold and increases in resistance as it heats up.

c. Voltage Divider Action by Tube Circuitry. The audio output tube voltage-regulator type of low-voltage source is illustrated by the Hallicrafter AR1200D chassis (Fig. 8-3). The maximum d-c supply voltage of 270v, represented by the heavy black lines, is fed to V115. The cathode, pin No. 8, supplies the 140-v line, represented by the heavy black and white lines. This is filtered by C118C and used to supply other sections of the receiver. V114 is direct-coupled to V115. The drop across the plate-load resistor of V114 supplies the bias for V115. The average grid voltage is therefore constant, due to the Class A operation of V114. As more current is drained by the external load from the cathode of V115, the voltage at this point decreases. This causes the cathode to be less negative with respect to the grid. Or, stated

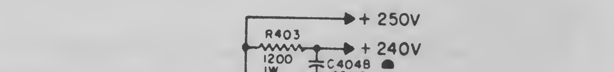


Fig. 8-2. Selenium low-voltage supply and filament circuit: GE 21T1.

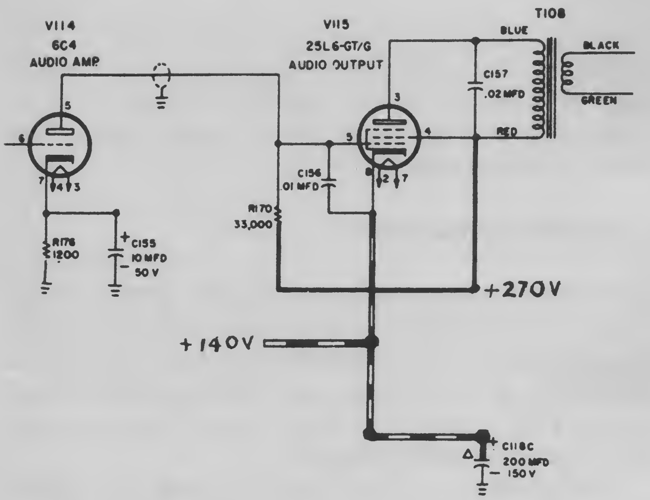


Fig. 8-3. Audio output voltage regulator: Hallicrafter AR1200D.

the opposite way, the grid becomes more positive with respect to the cathode. This condition forces more current to flow through V115 and thus tends to maintain a more uniform voltage at this point. It can also be shown that a decrease in current drain at the cathode of V115 reduces the current through the tube and tends to maintain a constant voltage output. In addition to the advantageous regulator action of this circuit, the usual resistive losses inherent in a voltage-divider network are eliminated.

A network of two tubes in d-c series is sometimes employed to supply B+ potential to these tubes. This arrangement is illustrated by the audio i-f section of the Motorola 21T4AC (Fig. 8-4). Sometimes, direct coupling can be used. In this case, the cathode of one tube is close to the d-c plate potential of the other tube. A network of this type reduces voltage-divider losses, and in some cases helps to eliminate resistance-type voltage dividers completely. At the present time this series-type network is used mainly in cascode r-f amplifiers and occasionally in the video and sound i-f's.

d. Identifying Characteristics

(1) *Power transformer supply.* This type of power supply uses a relatively large power transformer. Vacuum-tube rectifier (s), usually 5U4's, supply the necessary d-c voltages. Filament power for the receiver is obtained directly from the power transformer.

(2) *Selenium rectifier supply.* Two selenium rectifiers are connected to the line in a voltage-doubling circuit. The power transformer either is completely eliminated or is reduced in size to supply filament power only.

A-C/D-C Selenium-Rectifier Supplies, although not included in the above analysis, may be mistaken for the voltage-doubler power supply. The a-c/d-c receiver uses a simple half-wave selenium circuit. One

TABLE VI

Symptom	*Cause*
Set dead, filaments do not light	*Open* fuse, line cord, switch, interlock, power transformer winding, or filament in a series parallel string. No power in outlet.
Blows line fuse or smokes	*Shorted* power transformer, rectifier, B+ filter, filament, or filament line. Short from a hot chassis to a ground.
Set dead, filaments light	Defective rectifier, B+ short, open choke, speaker field, B+ or B– fuse, filter capacitor in voltage-doubler circuit, limiting resistor, power transformer winding, voltage divider, selector switch in phono or f-m
One filament, a string, or all filaments do not light	Open winding in power transformer, open connection in filament circuit, open filament or filament to cathode short in a series string, selector switch in phono or f-m position
Small or dim picture	Weak rectifier Defective filter capacitor. Low line voltage
Loss of either, or combination of, sound and picture (raster present)	Defective tube in voltage regulator or voltage divider circuit. Open oltage divider, shorted B+ capacitor
Hum in either, or in combination of, sound, picture, and raster	Open B+ filter Filament to cathode leakage Shorted choke
Incorrect voltage on low B+ line (130-v to 150-v line)	Shorted capacitor Open voltage divider Defective voltage regulator (audio output) tube
Low B– voltage	Improper bias on voltage regulator tube Shorted capacitor, cathode to filament short of any tube which has its cathode tied to B–. Open in B+ voltage divider
High B– voltage	Shorted B+ capacitor to ground; open B– voltage divider

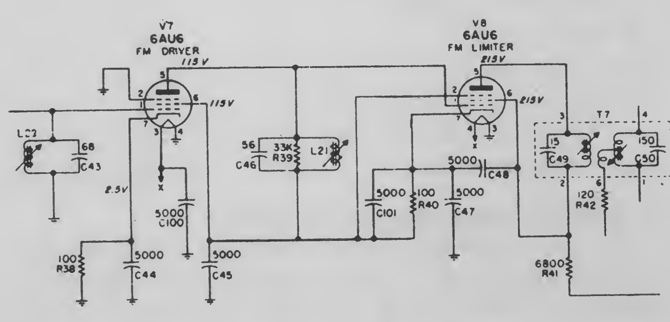


Fig. 8-4. Series B+ supply for two tubes: Motorola 21T4AC.

selenium rectifier is used which normally is capable of handling the power requirements. The d-c output voltage is approximately one-half that of the voltage doubler. Filament power is always obtained by a series-parallel arrangement directly off the line.

e. Possible Troubles in These Circuits. Some variations in circuit arrangements do exist, creating slightly different service problems. The following table will indicate some power supply defects and their possible causes.

II. TROUBLESHOOTING THE LOW-VOLTAGE POWER SUPPLY

A. Indications of Circuit Defects

Since all sections of the TV receiver depend on the power supply for voltage, a defect in any section may be due to power supply failure. Any one, or possibly a combination, of the following troubles may occur:

1. Set is dead.
2. Set blows fuses.
3. Small or no raster.
4. Weak or no sound.
5. Dim or no video.
6. Hum in video, sound and/or raster.

When any one, or a combination, of these troubles occurs, common and/or individual circuits are investigated for the presence of proper operating voltages.

As stated before, the low-voltage power supply may be the cause of many difficulties in a TV receiver, since all power originates in this section. Satisfactory operation depends on proper input line voltage and correct hookup of components. Where electromagnetic speaker fields are used, proper hookup of exact or equivalent parts must be used. An audio output transformer or choke mounted on a speaker frame and left in a customer's home for convenience might well be the cause for B+ discontinuity in the shop.

The type of power supply involved in the service operation should be analyzed initially. The defect should then be viewed with reference to peculiarities inherent in the particular type of supply. Isolation transformers should be used in the shop when transformerless receivers are serviced.

B. Instruments Used to Service the Power Supply

The following test instruments are used for servicing power supplies:

1. VTVM or VOM.
2. Wattmeter.
3. Tube tester.
4. Scope.
5. Selenium rectifier tester.
6. Capacity tester.

C. General Troubleshooting Procedure

The procedure outlined in Chapter 1 also applies to the low-voltage power supply, and therefore, should be followed here. Since all stages are involved in power supply defects, isolation to the power supply is not always immediately possible. Rapid checks should be made to establish which section is involved. The appropriate instrument (as listed in the preceding paragraph) should be used. In addition to normal a-c or d-c voltages, the voltmeter can be used to check for hum. The scope can be used to check for a-c, d-c, or hum voltages.

The wattmeter can be used as a guide to troubleshooting, to check for excessive or insufficient drain. In addition, the amount of drain can be noted with and without the rectifier circuit, thus establishing the amount of current drain due to the B+ or to any other section. See Chapter 2 for the technique of servicing with a wattmeter.

Visual inspection will often give important indications of the source of a particular defect. In addition to this, odors and smoke can lead directly to a fault. The characteristic odor of a defective selenium rectifier or an overloaded power transformer supplies important servicing information to an alert technician.

1. Servicing Procedure

a. Set is Dead. This condition brings the B+ power supply section under suspicion. Therefore, the troubleshooting process begins in the B+ power supply.

(1) *Transformer-type supply.* This type will be investigated first. (Refer to Fig. 8-1.) The input power is first investigated. Tube filaments are inspected for light.

If light is not present, the primary side of the power transformer is investigated. This includes the power from the line, the plug and a-c cable, the interlock, the "On-Off" switch, and the primary winding. In some receivers a fuse will also be located in this circuit.

If light is present, then the power transformer is receiving power. All the tubes in the receiver, with the exception of the high-voltage rectifier, receive filament power from the transformer. Therefore, they should all light. If one or a few tubes do not light, they should be checked. A filament winding of the power transformer may open and cause a string of filaments to be inoperative. Open connections in filament wiring can cause a group of filaments to be inoperative. In a receiver which does not employ a fuse in the B+ or B– circuit, the rectifier output circuit (+245-v line) should be checked for a short before replacing dead 5U4's.

The B+ output voltage is checked next. Since the fuse (F1) is available at the top of the chassis, this is checked for continuity. A voltage check can be made at the fuse terminals as an indication of the presence of B+ voltage. In Fig. 8-1 approximately 2v should be found on one side of the fuse and 2.5v on the other. This will give only an indication, and actual voltage checks should be made at the +245-v, +230-v, and +155-v lines. Loss of voltage at all these points may be due to an open fuse, open R49, open center tap on power transformer, shorted C63 or C64, or to a defective 5U4. Absence of voltage on the +230-v line only would be due to an open L16. Absence of voltage on the +155-v line only would be due to an open R84 or to a shorted C65.

(2) *Selenium-rectifier-type supply.* This type of supply (as shown in Fig. 8-2) will be investigated next. The receiver incorporates both a series string filament and a filament transformer. This reduces the service problem in regard to filament troubles in the transformer supply, discussed previously. The series filament can be completely or partially dead, due to one defective filament. An open filament would break the continuity of power, while a short from filament to cathode of V110 (cathode is at ground potential) would remove power from all filaments from that point to ground. The other tubes in the string would light much brighter, due to the increased voltage across them.

The Globar is checked by measuring the a-c voltage directly across it. The normal voltage is 10v, and any large variation from this value would indicate a defective Globar. If the string is open at any point, no voltage will be developed across the Globar. To determine whether the filament string is open on the low side of the Globar, an a-c voltage check should be made from this point to the main ground. A voltmeter reading close to 117v rms at this point indicates that the string is open from the low side of the Globar to ground. A tube tester or an ohmmeter can be used to check for an open filament or filament choke (L402 through L405).

Voltage checks may also be used by checking from the individual filaments to ground or across the individual filaments. The defect is indicated by a point of discontinuity. When testing from the filament string to ground, the open filament or filament choke will have 115v on one side and zero volts on the other side. Again, in an open filament string, *no reading* will be obtained when checking *across* a good filament, while 117v will be read across the defective filament or filament choke. This method of voltage check also speeds up the servicing procedure when trying to locate the intermittent filament (blinker).

The B+ output voltage is the next problem. An open fuse (F401, Fig. 8-2) or an open limiting resistor, R401, are the two most common causes for complete loss of B+ voltage. An ohmmeter should be used to check for a possible short in the B+ circuit before these parts are replaced. Other causes for complete loss of B+ include open C401, X402, or L401; or shorted C402 or C403A. For loss of B+ voltage in one section only, the resistor feeding the particular section should be investigated. This includes R403, R404, and R406. An open choke would cause the d-c voltage at the input side of the choke, L401, to rise approximately 20 percent. An open selenium (X401) would, on the other hand, cause a drop to less than one-half of the normal voltage.

b. A Short in Receiver. A shorted component that creates low B+ supply voltage can normally be located with an ohmmeter by following the path of the lowest resistance in a circuit. This will lead to the defect. Occasionally, however, dynamic testing is necessary if ohmmeter checks do not locate the source of the trouble. It is often necessary in both cases to disconnect some of the wires at a junction point, in order to determine which line is causing the short. In the latter case the trouble might lead to a shorted tube or to a coupling on a tube, which causes excessive drain only after the tube warms up.

If fuses blow at any time from the instant of application of power until the end of the warm-up period, it is first necessary to determine whether the trouble is in the B+ supply or in another part of the receiver. If a B+ fuse blows (Fig. 8-1, F1, or Fig. 8-2, F401), then the defect is in the B+ supply or load. However, in many cases a B+ fuse was not incorporated in the design or has been shorted out to facilitate servicing. It then becomes necessary to open the B+ circuit by removing the rectifier(s) of the B+ circuit in some other fashion. If the short disappears, then the trouble is in the B+ supply or load.

Fuses in the a-c line may blow requiring that an ohmmeter check be taken before applying voltage to the receiver. (A normal reading on a power trans-

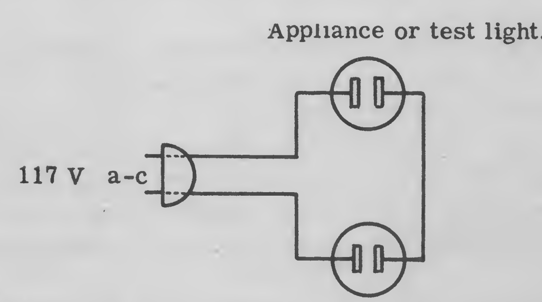


Fig. 8-5. Test jig.

former primary may be less than 1 ohm.) If this method does not lead to the defect (by following the path of the lowest resistance), then a test jig (Fig. 8-5) in series with the line may be used.

The test jig is a simple high-wattage lamp, heating element, or even another TV receiver, which is placed in series with the defective receiver. The jig is wired so that the a-c path is in series through the test appliance and the defective receiver. Thus, the test appliance is plugged into a-c receptacle No. 1, and the defective receiver into a-c receptacle No. 2 (Fig. 8-5). The jig is plugged into the line. If the test appliance lights up with close to, or at, normal brightness, then the receiver is shorted.

At this point suspected circuits are opened until the indication of a short disappears. If the fuse is good (F1, Fig. 8-1), or if the rectifier (s), V20 and V21, have been removed and the short still exists, then the power transformer and its associated circuits are checked. A short in the primary circuit may be investigated by opening one leg of the primary of T11. If the indication of a short remains at this point, then the defect is in X3, P3, SW1, R102, C75, or C76 or its associated wiring. If the short disappears, the transformer wire is replaced and the secondary circuit is investigated. Filament lines and the high-voltage secondary wires are removed one at a time. Any line that removes the short indication is the source of the trouble and should be investigated. If the short remains after all the secondary wires have been disconnected, then the power transformer, T11, is the source of the trouble. This method of disconnecting all secondaries may be used for a transformer which is overheating without blowing the a-c line fuse, to determine whether the defect originates in the power transformer or some other part of the receiver.

c. Low B+ at the Rectifier Output. This condition may be due to a short at some point in the B+, weak components, or an increase of resistance in a B– circuit. A short in the B– circuit may cause the B+ voltage to increase. However, if this B– short reduces the bias on certain tubes sufficiently, it may cause excessive current drain and balance out a B+ voltage increase.

Low B+ voltage at a specific point requires analysis of the circuit itself to determine the fault. Manufacturers' listings of voltages are confined to specific operating conditions. These include specified input voltages and input signals, with controls set at some definite point. Unless these conditions are adhered to, the voltages obtained may vary greatly from those listed.

Where the highest B+ voltage is low, the rectifiers are checked first. This may be accomplished by using a tube tester for vacuum tubes and a selenium rectifier tester for selenium rectifiers. Substitution of known good parts may also be tried. If rectifiers are not the source of trouble, other components are checked. Filter capacitors are bridged with test capacitors (for example, C402 and C403A in Fig. 8-2). The voltage-doubler capacitor, C401, and selenium rectifiers, X401 and X402, are also bridged. Polarity must be observed in all cases.

Shorts are checked next by testing the various output lines for a marked decrease from normal voltage. Assume the +240-v line to be exceptionally low as compared to normal, while the other lines are down an amount comparable to the main B+ line. The +240-v line would then be investigated. A resistance check at this point normally would localize the defect. In some cases troubles can be localized only by removal of one component, or a branch of components, from the circuit. This may lead to a part which shorts under voltage only; or to any tube which has an internal short, a leaky coupling capacitor on its grid, or loss of excitation that furnishes its grid bias.

d. Hum. The cause of this defect, which can be checked with an a-c meter (VTVM or VOM with capacitance in series) or with a scope, can affect the sound, the picture, or the raster. Hum can be caused by an a-c voltage (60- or 120-cycle) which enters a circuit through a defective tube, stray coupling, shorts, or improper grounds; or by improperly filtered B+ supplies. In this section only the latter type will be considered.

The full-wave type of power supply (Fig. 8-1) has a 120-cycle ripple in its output circuit, while the half-wave type (Fig. 8-2) has a 60-cycle ripple. In Fig. 8-2 it will be noted that C402 and C403A are much larger capacitors than C63 and C64, used in Fig. 8-1. This is necessary to fulfill the greater filtering requirements of the half-wave type of B+ supply.

Hum in the sound will show up as a steady humming noise, even with the volume control all the way down to minimum. Hum in the picture will show up as differences in picture shading vertically or in pulling in the picture in a horizontal direction. This condition causes a group of horizontal lines to receive more or less brightness than normal, or causes these lines to be shifted slightly out of line to the left or right.

Hum in raster can be checked by eliminating the video information and checking either side of the raster. It may be necessary to reduce the raster size or to shift the raster in order to examine the side. With hum present, the edge of the raster will be wavy and, if locked into sync with the hum, will resemble a sine wave. This sine wave may be either 120 or 60 cycles, depending on the type of B+ supply used.

It is not necessary to eliminate all the ripple in a

B+ supply in order to obtain satisfactory operation. Filtering networks are therefore designed with this in mind, and servicing problems should be concerned only with restoring normal operation. Hence, the normal ripple should be known. In Fig. 8-1 the +245-v line will have approximately 15v PP, while the +230-v line will have 1.5v PP. In Fig. 8-2 the input ripple to L401 will have approximately 30v PP, while the output will have 2v PP. Additional filtering is obtained at the lower voltage points by the filtering action of the series resistor and filter bypass capacitor.

A practical approach to the hum problem is to bridge the capacitors in suspected circuits. The limitations of this method become apparent when a defective capacitor snaps into operation during the bridging process. At this point the defective component can only be guessed at, unless it becomes defective again while under test. After this happens, it is sometimes possible to duplicate the original defective condition by removing suspected capacitors, one at a time. The removed capacitor which duplicated the original trouble is then replaced.

In a multiple capacitor containing several individual sections one or several of these sections may become defective. The scope or a-c voltmeter can supply valuable information when it is used to measure the ripple across each capacitor section. A suspected section is opened and a test capacitor is used to replace it. If this corrects the condition, the entire multiple capacitor should be replaced. If the trouble persists, the test capacitor is left in the circuit and the next suspected section is removed and a second test capacitor used to replace it. This process continues until all the sections have been tested. If any section is found defective, the entire multiple capacitor is replaced. In this connection it is important to note that the same replacement practice must be adhered to when replacing a section of a wire-wound voltage divider. The heat produced with normal operation may cause the defective section to become erratic. This would cause voltage changes in the receiver if the replacement part were simply bridged across the defective part. It is therefore good practice to replace the entire tapped resistor rather than just a defective portion.

e. Voltage-Regulator Circuits. These circuits, sometimes incorporated into the audio output tube (Fig. 8-3), may cause trouble in the low B+ line. Troubles in this circuit may be due to either V115, V114, or their associated circuitry, because of the direct coupling between the two tubes. It is evident that a shorted V114 would cause the grid of V115 to go more negative, while weak emission from V114 would cause the grid to go more positive. This is due to the fact that the grid bias on V115 is partially controlled by the voltage drop across R170, one end of which goes to the high B+ and the other end to V114 plate. A variation of this circuit is seen in Fig. 8-4. In this case the tubes supply their own bias. If either one of the tubes becomes defective or is removed from its socket, the other tube automatically becomes inoperative. Hence both tubes must be investigated when B+ troubles exist.

2. PREVENTIVE MAINTENANCE AND PARTS REPLACEMENT

a. Rectifier Performance. This is checked with a tube tester, a selenium rectifier tester, by substitution, or by receiver voltage checks.

Voltage checks and/or parts substitution may also be made to determine the condition of filter and voltage-doubler capacitors. Seleniums with correctly rated current-carrying capacity should be used for replacement. Where two rectifiers are used (Fig. 8-1, V20 and V21), each tube should be checked individually to prevent a weak 5U4 from placing all the strain on a good one. All 5U4's should be gently tapped to see that no loose particles are present, since this could cause a short. A fuse that seems to blow for no apparent reason can often be traced to this flaking condition in a 5U4.

b. The Fuse and A-C Line Cord. This should be examined. A blown fuse should always be replaced with one which meets the manufacturer's specifications. The a-c line cord and male plug should be checked for frayed or exposed conditions. The interlock pins on the chassis should be firm and make good electrical contact to the internal soldering lugs. A loose rivet in the interlock may often be remedied by soldering it. Where necessary, the interlock is replaced. Fuse holders should be checked for corrosion and poor spring contact.

c. Other Considerations

(1) A Globar resistor that takes 2 min or longer to bring a receiver into operation should be replaced. A Globar of proper value should be used for replacement.

(2) Lamination buzz may be eliminated or reduced by tightening the transformer bolts. This may require that the mounting nuts that hold the transformer to the chassis be loosened first. The transformer bolts are then tightened and then the mounting nuts are retightened. In some cases shellac may be applied to a loose lamination, or in the extreme case, replacement of a transformer may be required to eliminate buzz.

D. Home Servicing Techniques

In general, all the techniques previously mentioned may be applied in the home. The only limitation is the amount of equipment brought into the home. In addition, check the line voltage and a-c receptacle.

CHAPTER 9. FRONT END SERVICING

I. FRONT END OPERATION

A. Introduction

1. Function. The front end, or tuner, selects the channel to be viewed, then amplifies and converts the channel sound and picture carrier frequencies to lower intermediate frequencies. The video i-f carrier retains the amplitude modulation of the original video carrier. The sound i-f carrier retains the frequency modulation of the original sound carrier.

2. Component Stages in Front End. This section consists of:

a. R-F amplifier.
b. Oscillator.
c. Mixer.

3. Input and Output Signal Frequencies. The signals of all the TV channels, and of other radio services which the antenna intercepts, induce their signals in the TV antenna. For this reason the tuner must be frequency-selective, so that the viewer may choose (tune to) the channel which is carrying the program he wishes to see.

a. Input Frequencies

(1) *VHF frequencies.* Frequencies of Channels 2 to 6 are:

Channel	Low Side (mc)	Pix Carrier (mc)	Sound Carrier (mc)	High Side (mc)
2	54	55.25	59.75	60
3	60	61.25	65.75	66
4	66	67.25	71.75	72
5	76	77.25	81.75	82
6	82	83.25	87.75	88

Channels 7 to 13 are all adjacent channels, each occupying 6 mc. These start at 174 mc (low side of Channel 7) and go through 216 mc (high side of Channel 13). The picture carrier of each is 1.25 mc above the low side, and the sound carrier of each is 0.25 mc below the high side.

(2) *UHF frequencies.* The 70 uhf channels (Channels 14 through 83) start at 470 mc (low side of Channel 14) and extend to 890 mc (high side of Channel 83). Each uhf channel is 6-mc wide and is constituted in exactly the same fashion as the vhf channels. For example, the frequency distribution for Channels 14 and 15 is as follows:

Channel	Low Side (mc)	Pix Carrier (mc)	Sound Carrier (mc)	High Side (mc)
14	470	471.25	475.75	476
15	476	477.25	481.75	482

All uhf channels are adjacent channels.
28 - 554 - 555.25 - 559.75 - 560
83 - 884 - 885.25 - 889.75 - 890

A simple formula to find the low-side frequency of any uhf channel is:

$$F = 6N + 386 \qquad (a)$$

where F in megacycles is the desired low side frequency and N is the channel number.

For example: To find the frequency range of Channel 16, substitute 16 for N in formula (*a*)

$$F = 6\,(16) + 386 = 482 \text{ mc}$$

Therefore, the frequency of Channel 16 is 482 to 488 mc.

Most receivers manufactured today have some provision for selecting both vhf and uhf channels. The usual arrangement is to have the receiver capable of selecting all the vhf channels, and some or all of the uhf channels. If the receiver does not already have a uhf tuner, either there is space on the chassis for adding a uhf tuner or converter or provision for adding uhf strips for receivers using a strip turret tuner. An alternative is the use of a uhf converter, separately housed, which is placed on top of the TV cabinet and connected to operate in conjunction with the receiver.

b. Output Frequencies

(1) *VHF tuners.* The vhf tuners utilize a single heterodyne system. The TV and sound signals fed from the r-f amplifier to the mixer beat with the r-f signal generated by the local oscillator. The difference frequencies (i-f's) are selected in the plate of the mixer and are fed to the i-f amplifiers. The i-f frequencies are either in the 20-mc or 40-mc band.

(2) *UHF tuners.* These offer two different types of output frequencies. In the first type, the uhf tuner converts the incoming uhf signal to the regular i-f frequency of the TV receiver. It is then fed to the i-f amplifiers. This involves a single heterodyne principle, just like the vhf tuner.

In the second type, the uhf converter operates on a double-heterodyne principle. The converter receives the uhf channel signal, and by the first heterodyne action, reduces it to the signal frequencies of either Channel 5 or Channel 6, depending on which channel is inactive in a particular locality. This signal is then fed to the vhf antenna input and the vhf selector set to Channel 5 or 6, respectively. Then, by normal vhf action, the second heterodyne reduces the signal to the i-f frequency of the receiver.

In all cases the original modulation is retained in the new i-f video and sound carriers.

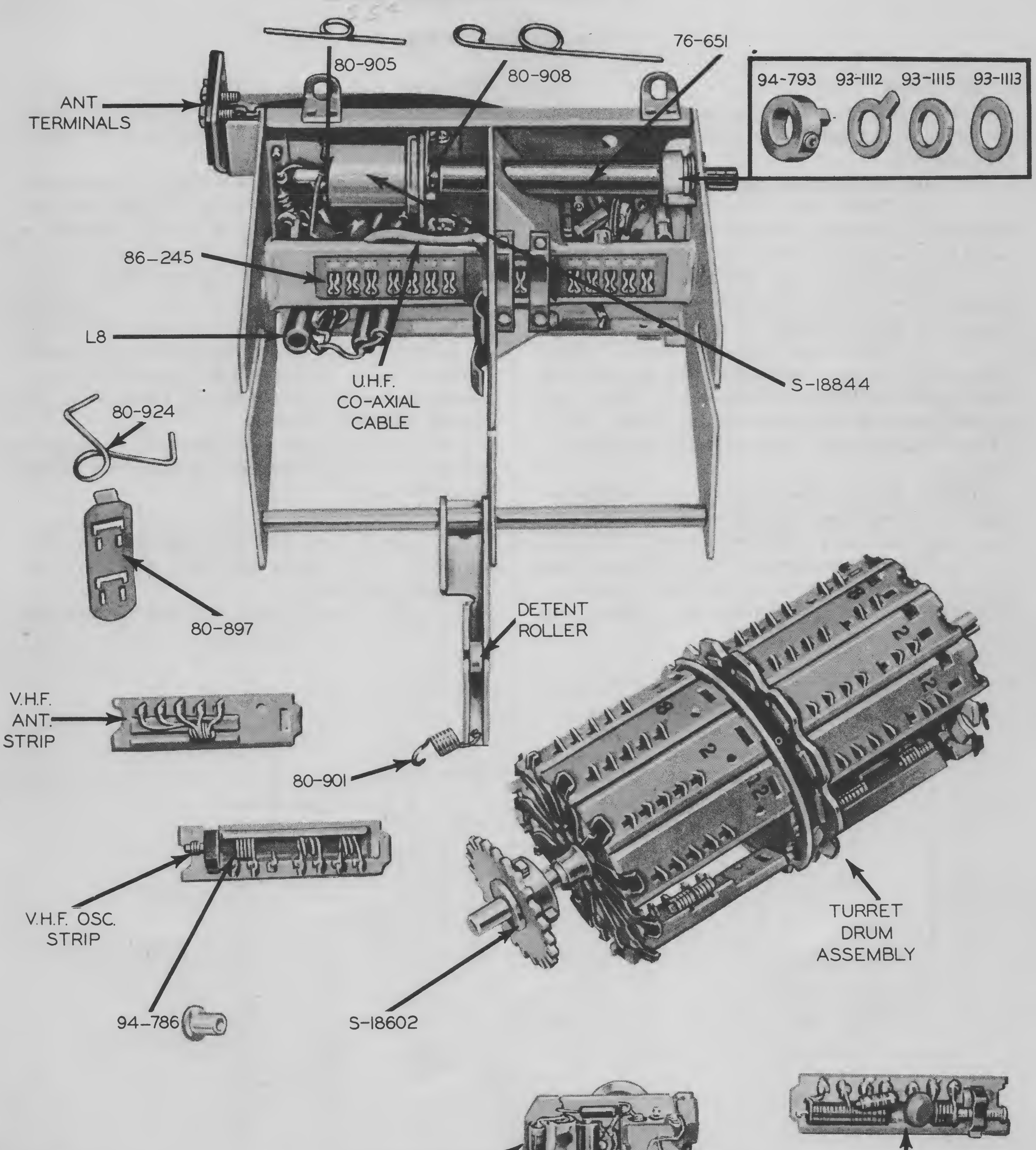


Fig. 9-1. Exploded view of turret tuner: Zenith 19L27.

II. CIRCUIT COMPARISONS

(Latest Receiver Models)

A. VHF Tuners

1. General. Both the mechanical features and circuit arrangement must be considered in comparing vhf front ends.

a. Mechanical Arrangement

(1) *Turret tuner.* This features a rotatable drum with removable strips. On these strips are the tuned circuits for each of the channels (see Fig. 9-1).

(2) *Wafer switch.* The wafers are fixed. A moving contactor selects the tuned circuits wired to each of the wafer positions.

(3) *Continuous tuner.* There are several types. In the Mallory Inductuner a moving contactor selects different lengths of inductance. Other continuous tuners feature a core moving in and out of a fixed coil. Both these types are variable inductance tuners.

One-half the receivers analyzed use a turret-type tuner. The remainder use a wafer switch tuner, except one, which has a continuous tuner.

b. Circuit Arrangement. These characteristics will be compared: type of r-f amplifier, cascode or noncascode; tuning arrangement of oscillator and other front end circuits (whether series-tuned or individually tuned circuits); and variation of inductance or capacitance in the continuously tuned circuits.

A survey of current models showed that cascode r-f amplifiers are used in 90 percent of the front ends.

Individually tuned oscillator circuits, featured in the turret tuner, are used in 50 percent of the receivers, with the remainder using series-tuned circuits.

In the series-tuned arrangement the coils are wired up in series. The junction of any two coils is connected to a position on the wafer switch. The switch contactor shorts out more inductances as the switch is rotated toward channel 13. On Channel 13, the smallest inductance remains.

The only continuously tuned front end investigated employs a variable inductance (a core moves in and out of the coil).

c. Tubes Used

(1) *R-F amplifier.* The most popular tubes are 6BQ7, 6BK7, 6BZ7, and 6BC5; also found are the 6AB4 and 6AK5.

(2) *Mixer-oscillator.* The most popular tube

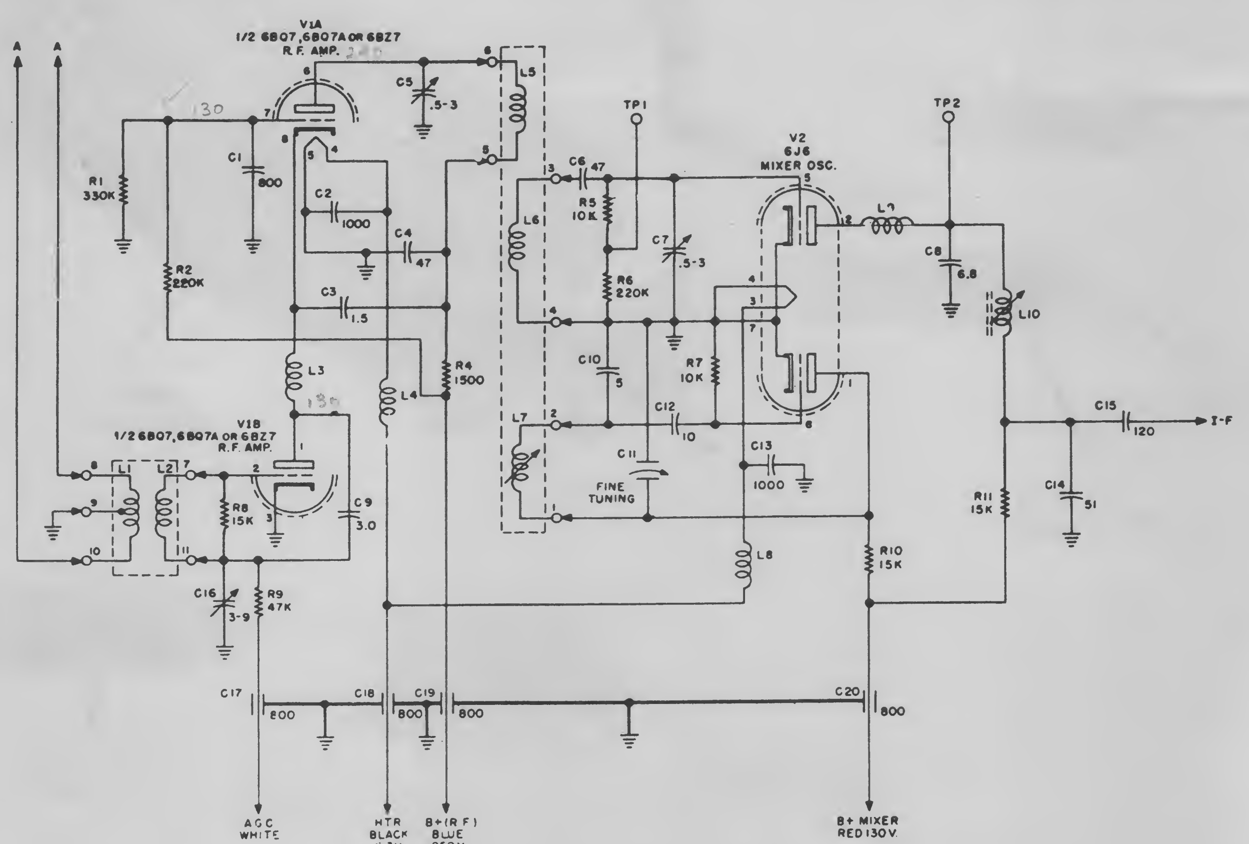


Fig. 9-2. Turret tuner: Crosley 405.

used is the 6J6 as a combination mixer-oscillator; also found are the 6U8, 6X8, 12AT7, and 12AZ7.

2. TURRET TUNER EMPLOYING CASCODE R-F AMPLIFIER. Typical of front ends employing a turret tuner and cascode r-f amplifier is that used in the Crosley 405 (Fig. 9-2).

The tuner consists of a dual triode, either the 6BQ7 or 6BZ7, connected in cascode, and a 6J6 which combines the functions of mixer and oscillator. The tuned strips are mounted on the rotatable turret. There are two strips for each channel (L1 and L2 in Fig. 9-2). The antenna strip holds the primary and secondary coils. The second strip holds the coils for the plate of the r-f amplifier, L5; grid of the mixer, L6; and oscillator, L7. The inductance of L1, L2, L5, and L6 is fixed. The oscillator coil, L7, is made variable by a core adjustment, accessible from the front.

a. R-F Amplifier. V1A and V1B, two triodes connected in series, constitute the r-f amplifier. This series arrangement is characteristic of the cascode amplifier. The cathode of the input tube, V1B, is grounded. The plate of V1B is connected through L3 to the cathode of V1A. This provides for direct coupling of the signal to V1A. The grid of V1A is kept at r-f ground potential by C1. The grid of V1A is maintained at a high d-c positive potential by the divider action of R1 and R2 to offset the high positive voltage on the cathode.

The cascode circuit affords more gain than that obtained from a pentode r-f amplifier. Moreover, the noise developed by the triodes is less than that derived from a pentode. Hence, we have an amplifier giving high gain combined with a low noise factor.

The 6BQ7 is a specially designed high G_m nine-pin miniature dual triode. Each triode has a separate cathode. An internal shield is located between these two tubes to minimize coupling and interaction and is connected to pin No. 9, which should be grounded. Moreover, the grounded grid (r-f) in V1A acts as a shield between the plate and cathode of that tube and reduces the tendency of that triode to oscillate.

L1 provides a balanced 300-ohm input to V1. R8 across L2 gives this tuned circuit the necessary bandwidth. C16, in conjunction with L2, tunes the grid circuit. C5 and L5 tune the plate circuit of V1A. C16 and C5 are adjusted in alignment. AGC bias is fed to the grid of V1B through R9. C17 is a feed-through capacitor in this line. L3 and C9 combine with the wiring and heater-to-cathode capacity to form a tuned interstage coupler which favors the high-channel frequencies. This compensates for the tendency of the circuit to fall off at the high end. C9 also provides some positive feedback to the grid of V1B through L2, to overcome the degenerative feedback from plate to grid through the tube capacity. R4 and C4 provide plate decoupling for V1A. Filament decoupling is obtained by C2 and L4.

b. Mixer. The top triode of V2, a 6J6, acts as the mixer. The r-f and oscillator signals are inductively coupled to L6, in the grid circuit. L6, in parallel with C7 and the stray and tube capacity, tunes this circuit. The cathode of this mixer is grounded. C6, together with R5 and R6, forms the grid-leak combination. C7 is made variable for r-f alignment. The junction of R5 and R6 is brought out to the chassis as test point 1 and is used in oscilloscope alignment. R5 isolates the scope from the grid of the mixer. L10, in the plate circuit of the mixer, is made variable for i-f alignment. The junction of L9 and L10 is brought out to the top of the tuner as test point 2, for use in i-f alignment.

c. Oscillator. The bottom half of V2 is wired up as an ultraudion oscillator, a variation of the Colpitts. The circuit is tuned by L7, C11 (fine-tuning control), and fixed capacitor, C10. R10 is a voltage dropping resistor and C20 a feed-through capacitor to keep r-f out of the B+ supply. C12 and R7 constitute the grid-leak combination. L7 is made variable, for setting the oscillator frequency. There is a separate coil for each channel, and adjustment of this coil on any one channel does not affect oscillator frequency on any other.

The i-f's are in the 20-mc range in this circuit. It should be noted that turret tuners are also available and are widely used in the 40-mc i-f range.

d. Possible Troubles. Failures in this tuner may be either electrical or mechanical.

Electrical defects include component failures, such as tubes, capacitors, resistors, and coils. Defective channel coils will show up as troubles for a specific channel. However, it should be noted that component failure is usually limited to tubes.

After tube failures, the next likely sources of trouble are mechanical. The most common cause of noisy or erratic tuner operation is dirty contact points. These may be cleaned with a commercial contact cleaner preparation, and lubricated with a pure mineral oil.

Contact spring pressure may be a cause of trouble. Contact rise should be about 1/32 in.

Noisy channel switching may result if the detent spring roller does not rotate on the detent plate. This can be corrected by lubricating this part with grease or vaseline.

Frequent removal of tuner strips may result in decreased tension of the clip spring holding the strip. This may cause erratic operation on a particular channel.

Oscillator slugs for a channel may fall into the coil form when they are improperly adjusted. This will

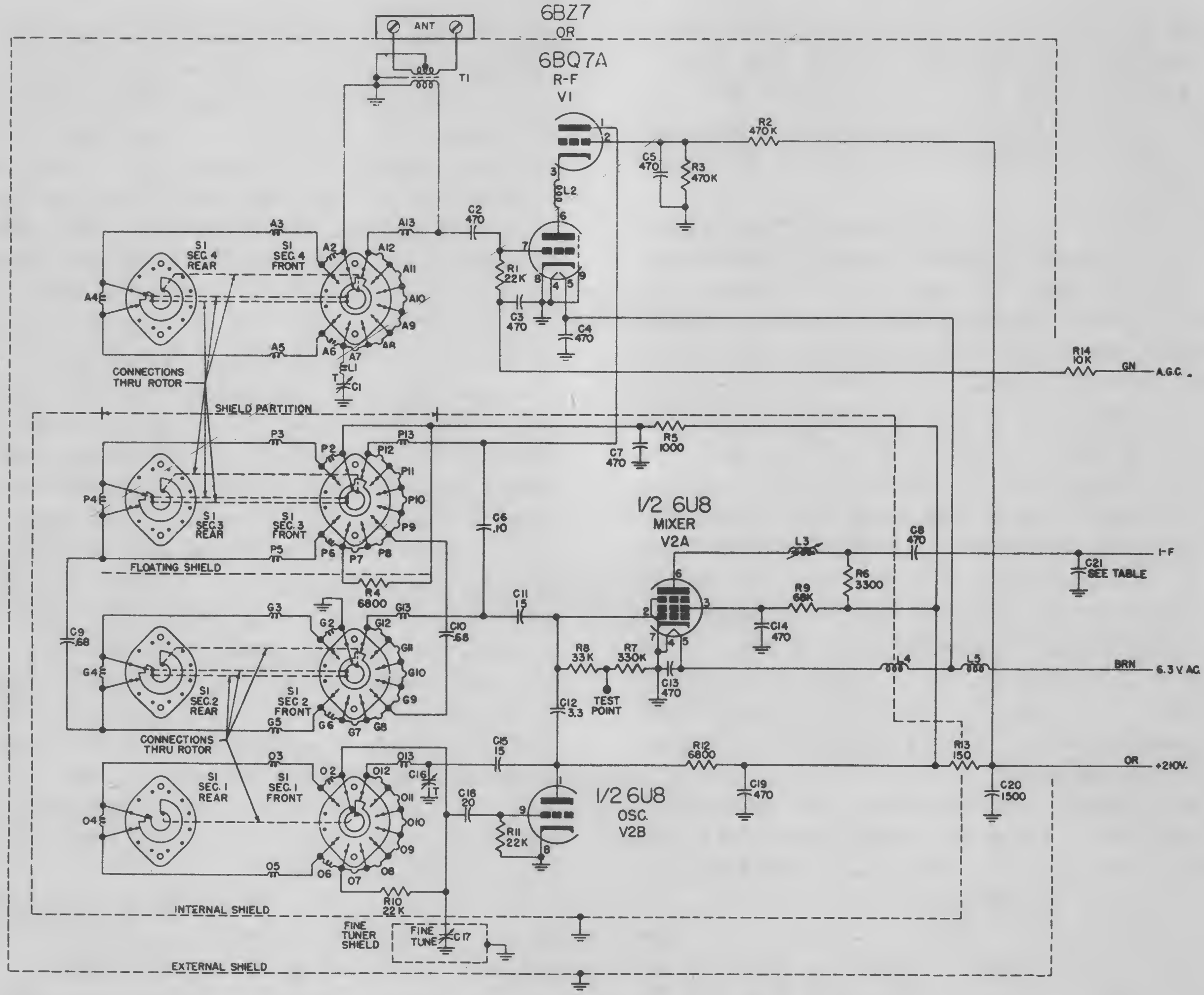


Fig. 9-3. Switch wafer vhf tuner: Magnavox 105 chassis.

disable the particular channel until they are properly reinserted.

The fine-tuning shaft may bind and require cleaning and greasing.

3. Switch Wafer Tuner Using The Cascode R-F Amplifier

a. General. Figure 9-3 is the schematic diagram of a switch wafer type of tuner, used in the Magnavox 105 chassis. The essential difference between this and the tuner just described is that the tuned coils are mounted at connector points on the ganged wafers of the switch. Tuning is accomplished by moving fingers on each wafer, which select the contactors. Another difference is that the channel coils are all wired in series on the wafers. Refer to Fig. 9-3 in which the Channel 13 position is shown. Antenna wafer shows that coil, A13, only is in the grid circuit of the r-f amplifier. The other coils are shorted by the grounded common finger. If the switch were moved to Channel 12, series coils, A13 and A12, would be in the circuit. The same arrangement holds for selection of the tuned circuits in the mixer and oscillator.

b. R-F Amplifier. V1 is a cascode amplifier using a 6BZ7 or 6BQ7, whose operation is the same as that described in Fig. 9-2. C1 is a tuning adjustment for the lower channels and is set on Channel 6.

c. Oscillator. V2B is the triode section of 6U8. It is connected as an ultraudion oscillator. It is tuned by the coils on section 1 wafer. Tuning for Channel 13 is accomplished by coil, O13; trimmer capacitor, C16; the fine-tuning control, C17; and the circuit and stray capacities. Channels 7 through 12 may be adjusted by moving their coils up or down. These coils, O7 through O12, are either a turn or part of a turn. Channels 2 through 6 are each tunable by varying the spacing of their turns. The output of the oscillator is fed to the mixer by C12.

d. Mixer. The pentode section of V2A acts as the mixer. The junction of R7 and R8 is a test point and is brought out to the top of the tuner for aligning and testing purposes. Grid injection voltage at this point should normally be about 3v *negative.* The plate of the mixer is tuned in the 40-mc i-f range by L3.

It should be noted that the coils on wafer sections 1 through 4 are adjustable by spreading or compressing them. Normally, this should not be required since they are factory set. Further, any adjustment (capacitor or inductance) will affect all the channels below the point of adjustment but not above. Therefore, in aligning this circuit the technician starts with Channel 13 and goes successively to Channel 2.

e. Troubles in the Circuit. Electrically, troubles due to component breakdown are the same as in the turret tuner previously discussed. Mechanical troubles can also affect operation of this tuner.

Mechanical defects include poor and/or dirty switch contacts, failure of detent mechanism (so that switch cannot click into position properly), poor solder connections, shorted plates of the fine-tuning control, and poor electrical connections of connectors through rotors.

4. Continuous Tuner

a. General. Figure 9-4 is the schematic diagram of a continuously variable tuner found in the Raytheon 17T1 chassis. A dial drive moves a core in and out of the stationary coils, varying their inductance. The r-f amplifier, mixer, and oscillator cores are all ganged to this drive mechanism. An associated switch selects coils for either the low channels (2 through 6) or the high channels (7 through 13). In the position shown in Fig. 9-4 the high-frequency coils and capacitors are in the circuit.

b. R-F Amplifier, Mixer, and Oscillator. The 6BK7 is a cascode r-f amplifier, identical in operation to similar circuits previously discussed. The high-low channel switch automatically selects either T1A or T1B, respectively, when the tuning selector has been rotated through its entire range. AGC bias feeds input grid, pin No. 2 of the 6BK7. Output grid, pin No. 7, is brought to r-f ground potential by feed-through capacitor, C10. Control grid, pin No. 7, and cathode, pin No. 8, are maintained at the same d-c potential by r-f coil, L-2.

One half of V2, a 12AT7, is used as an oscillator. The other triode in the 12AT7 is used as the mixer. Grid-leak bias is developed in the mixer across the series combination of R6 and R7. The junction of R6 and R7 is brought out on the tuner chassis as a test point in testing and alignment.

The plate circuit of the mixer is tuned to the i-f range. The sound i-f carrier is 22.25 mc and the video i-f carrier is 26.75 mc.

c. Possible Troubles in the Tuner. The usual tuner troubles may occur here. These are: open or high-resistance ground or coil solder connections, defective tuning core, trimmers or coils, and defective switch contacts. Dial drive slippage and broken coils may present problems. In addition, component failures, such as tubes, resistors, and capacitors may introduce trouble.

B. UHF Tuners

1. General Information. When the FCC lifted the TV freeze in 1952 and authorized the licensing of uhf stations, 70 new uhf channels were made available. This represents approximately six times the number of vhf channels provided in the vhf band. To the service industry, this means hundreds of new TV stations, and millions of new receivers and viewers throughout the nation, with countless new service opportunities.

For the practicing technician, uhf presents an ex-

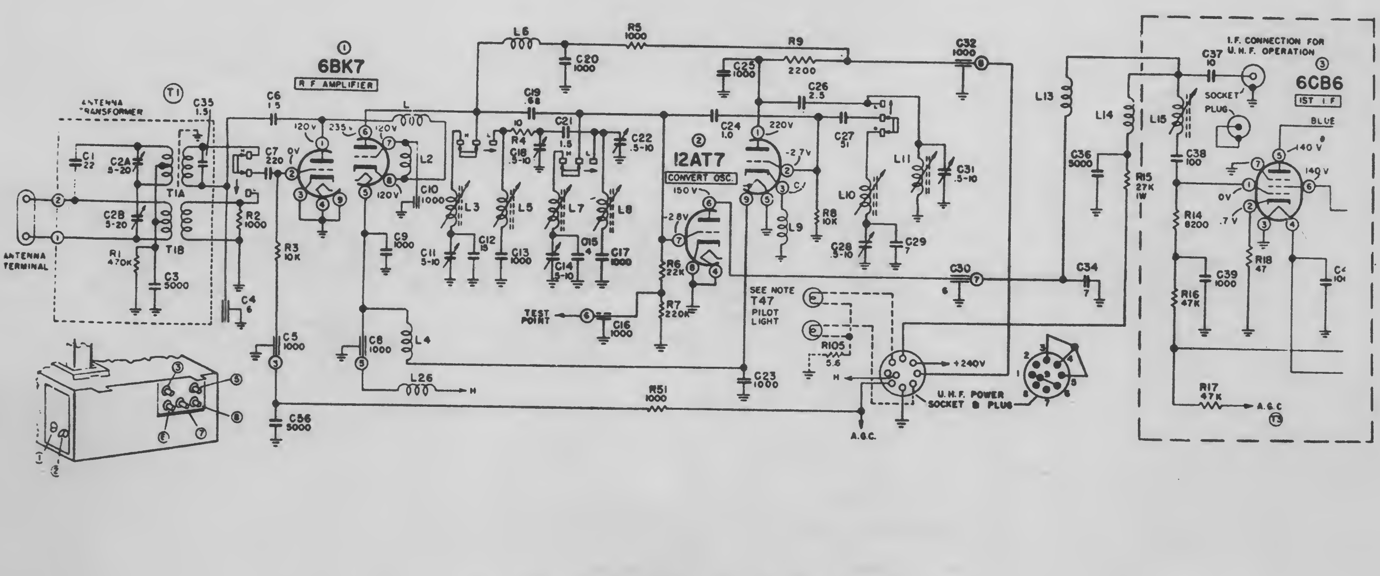


Fig. 9-4. Continuous vhf tuner: Raytheon 17T1.

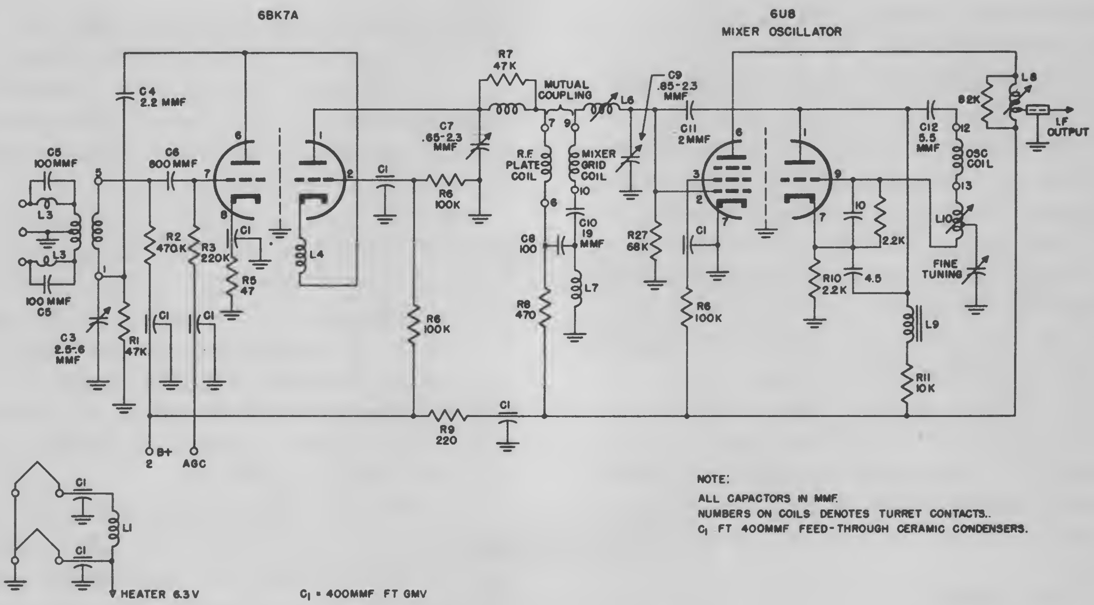


Fig. 9-5. Turret Tuner: Zenith 19L27.

tension of TV principles with which he is well familiar. The only difference between a vhf receiver and a uhf receiver is in the front end. The vhf tuner selects Channels 2 through 13, lying in the frequency range 54 mc to 216 mc. The uhf tuner selects Channels 14 through 83, in the 470-mc to 890-mc band. The rest of the TV receiver is the same. A vhf receiver becomes a uhf receiver by the addition of a uhf tuner or converter. However, the higher frequencies require new design and service techniques. Hence, the uhf front end is considerably different from its vhf counterpart.

2. UHF Strips for Turret Tuner. The turret tuners (Figs. 9-2 and 9-5), which use individual channel strips, are easily adaptable for uhf reception, simply by the addition of uhf strips. Turret tuners usually contain 12 sets of strips for each of the vhf channels. A maximum of seven vhf channels is alloted to any one area. Hence, five vhf strips may be removed and replaced with uhf strips. Figure 9-1 shows the uhf strips available for the Zenith turret. Similar strips can be obtained for the Standard tuner, used in many TV receivers. However, circuit operation of these strips in the Standard tuner is somewhat different from that in the Zenith turret tuner.

a. Zenith Turret Tuner. Figure 9-6 is a block

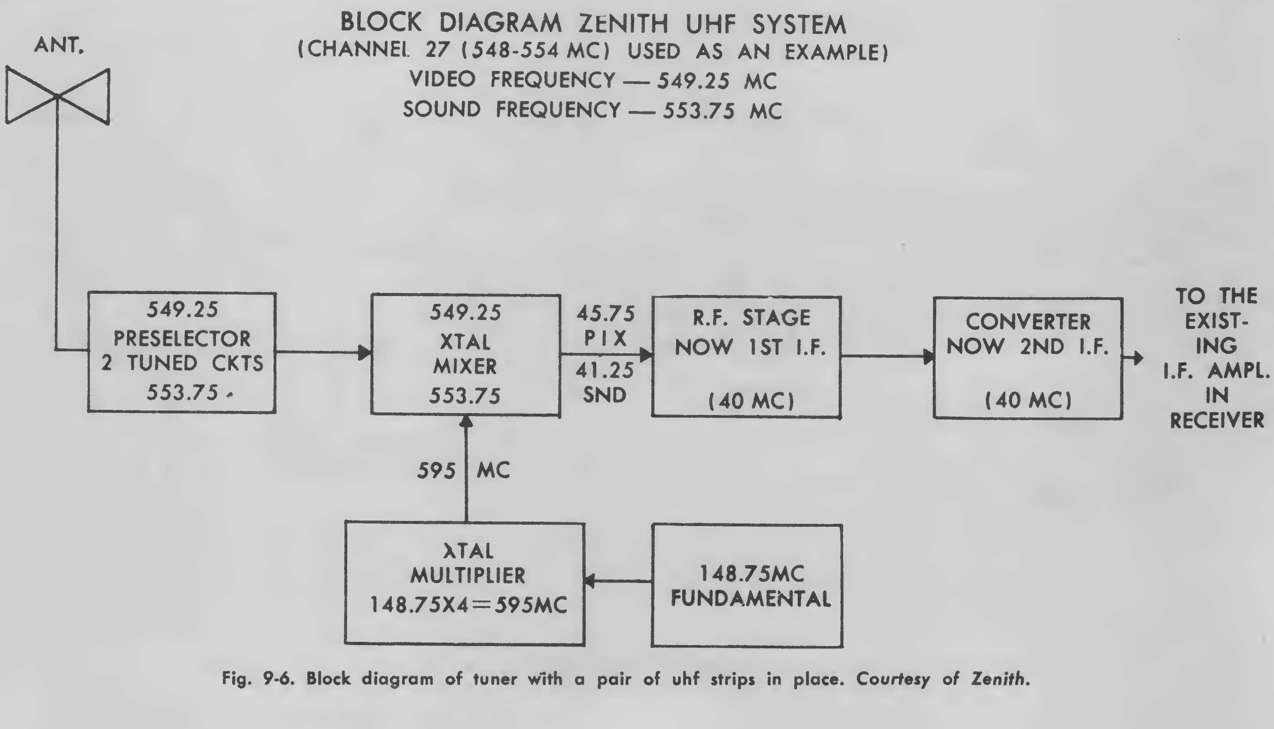


Fig. 9-6. Block diagram of tuner with a pair of uhf strips in place. Courtesy of *Zenith*.

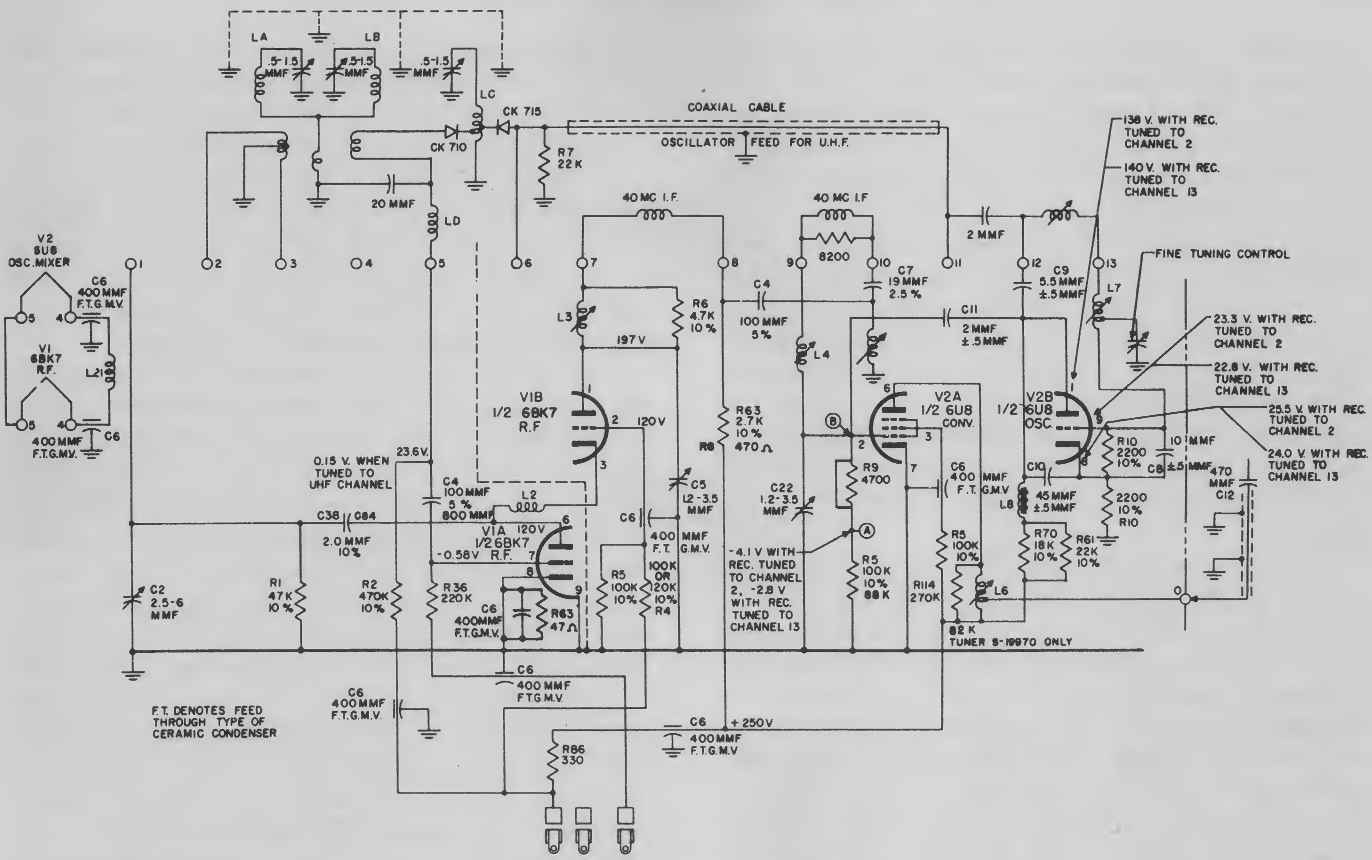


Fig. 9-7. VHF-uhf front end: Zenith.

diagram of the front end of a Zenith tuner with a pair of uhf strips in place. Compare Fig. 9-5 with Fig. 9-7, showing the Zenith front end set up for vhf and for uhf reception.

(1) *VHF.* In Fig. 9-5, V1, the 6BK7, is a conventional r-f cascode amplifier, selector-tuned to the incoming channel frequencies. V2A and V2B, pentode and triode sections of a 6U8, act as the mixer and oscillator, respectively. The oscillator is tuned above the incoming channel frequencies. On-channel the plate of the mixer contains the sound and picture i-f carriers (41.25 mc and 45.75 mc, respectively) and their attendant modulation. The vhf strips (two for each channel) mounted edge to edge provide the coils for tuning the oscillator, r-f amplifier, and mixer.

(2) *UHF.* The insertion of two uhf strips for a particular channel alters the circuitry of the front end. Figure 9-6 shows, in block diagram form, how the circuits of Fig. 9-5 were altered by the insertion of the uhf strips. It should be noted that all the changes are incorporated on the strips and are automatically made by turning the channel selector from a vhf to a uhf position.

The uhf strips contain:

(a) The preselector-tuned circuits for a particular uhf channel.

(b) An oscillator coil, which is slug-tuned (as are the regular vhf oscillator coils). The oscillator fundamental is actually set in the vhf band. Harmonics of the oscillator are used for beating with the incoming signal frequency to obtain the i-f range.

(c) A crystal multiplier, which generates oscillator harmonics and is placed between the oscillator and crystal mixer.

(d) A crystal mixer, which beats the proper oscillator harmonic with the incoming r-f signal, down to the 40 mc i-f range.

(e) Coils for tuning the r-f grid and plate, and the converter grid to the intermediate frequency.

This tuner utilizes a single conversion system in which the carrier beats with the oscillator to obtain the vhf i-f in one mixing operation. The incoming uhf signal is selected by preselector-tuned circuits and applied to the crystal mixer. The oscillator signal is fed to a crystal multiplier which rectifies it. The rectified signal is rich in harmonics, and the proper harmonic is selected by a tuned circuit and coupled to the crystal mixer. The output of the crystal mixer is the receiver i-f, and this is amplified by the cascode r-f amplifier (V1), which now acts as a first i-f amplifier, and by the converter (V2A), which acts as a second i-f amplifier. The output of V2A goes to the receiver i-f circuits.

Refer to Fig. 9-7 for the front end circuits utilizing the uhf strips. LA and LB, the preselector coils, are tuned to the incoming uhf carrier frequencies. They

constitute a double-tuned preselector into which the antenna signal (brought in at Points 2 and 3) is coupled. The r-f signal is then coupled inductively to the mixer crystal, CK710.

V2B is the local oscillator, whose frequency can be set by adjusting the core of the oscillator coil mounted on the oscillator strip. However, the main oscillator coil, L7, is located on the tuner chassis.

The oscillator signal is fed through the 2-mmf capacitor to the crystal multiplier, CK715. This crystal conducts on the peaks of the oscillator sine waves. The rectified signal is therefore rich in oscillator frequency harmonics. The circuit consisting of LC and its trimmer is tuned to the proper harmonic. Hence, the required harmonic is also fed to the mixer.

In the output of the mixer is a low-pass filter consisting of the 20-mmf capacitor, and LD and C4, which accepts the i-f but rejects the uhf signal. The i-f signal is thus brought to the grid of V1, the vhf cascode r-f amplifier, which is now converted to a cascode i-f amplifier by tuning the plate circuit of V1B to the i-f range (by the 40-mc i-f coil between contactors 7 and 8 on the strip). The output of V1B is coupled to the grid of V2A, former vhf converter, whose input is also tuned to the 40-mc i-f range (by the 40-mc i-f coil between contactors 9 and 10 on the strip). The output of V2A then goes to the i-f amplifiers in the usual manner.

To understand the conversion process, assume that the uhf strips are set for Channel 27, 548 to 554 mc (see Fig. 9-6). The video carrier is 549.25 mc, and the sound carrier is 553.75 mc. The oscillator frequency is set at 148.75 mc. The fourth harmonic of 148.75 mc (595 mc) in the output of the crystal, CK715, is selected by LC, which is tuned to 595 mc. This signal is applied to the crystal mixer, CK710, and beats with the incoming channel signal. The resultant i-f carriers, 45.75 mc and 41.25 mc, appear in the output of CK710 and are fed to V1. After amplification by V1 and V2A, the i-f amplifier and the receiver operate normally on this signal.

b. UHF Strips for Standard Tuner. Strips for the Standard tuner use a double-conversion system for uhf selection. The uhf signal is heterodyned to a lower frequency in the vhf band. It then passes through the vhf front end in the usual fashion and is converted again to the regular receiver i-f frequencies. In this process the local oscillator is used twice.

Figure 9-8 illustrates this. The channel signal is selected by the r-f preselector (L2, C2, L3, and C3). The crystal mixer, CK710, receives this signal. The oscillator frequency is set in the vhf range and the signal is brought to the crystal harmonic generator, 1N60. The harmonic selector, L4 and C4, is tuned to the proper oscillator harmonic and feeds this signal into the crystal mixer. The difference frequency in the output of the mixer is inductively coupled by T1 to the grid of vhf r-f tube. After amplification, this signal is coupled from the plate of the r-f tube to the grid of the vhf mixer. The oscillator fundamental also is coupled to the grid of the vhf mixer. After this second heterodyning, the uhf signal is reduced to the receiver i-f.

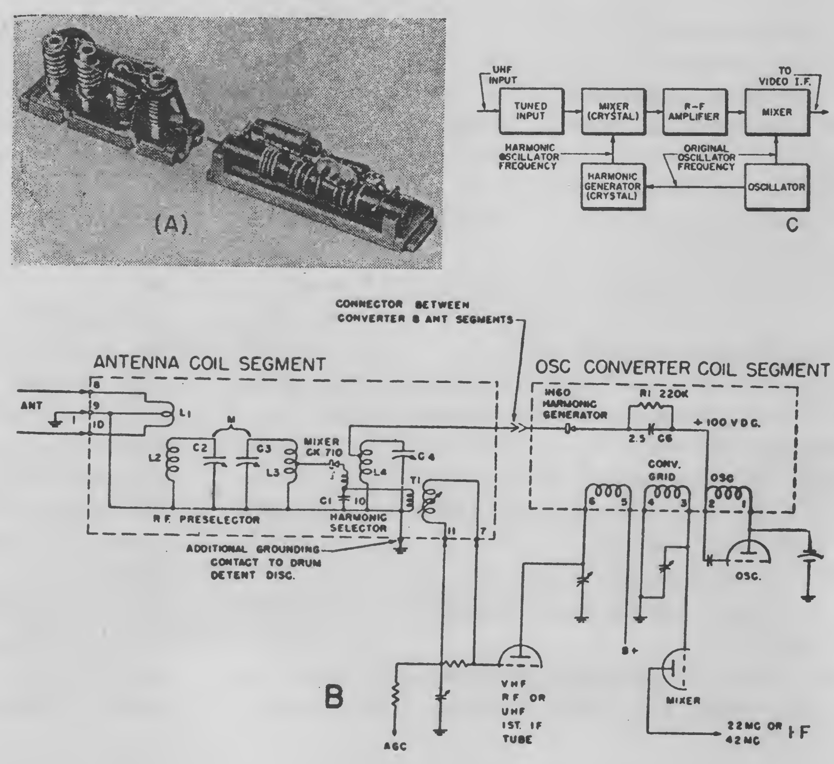


Fig. 9-8. Standard tuner uhf strips.

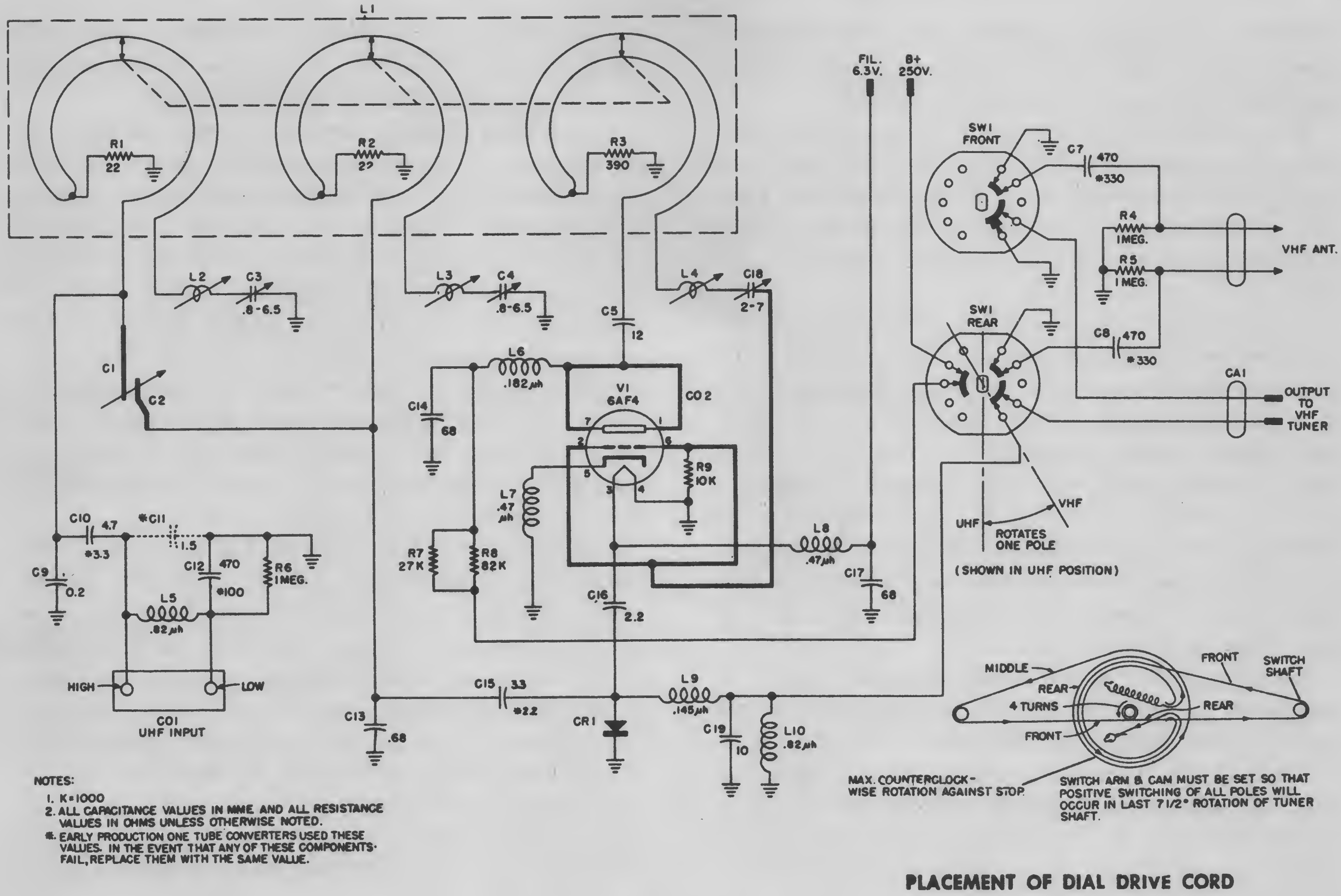


Fig. 9-9. UHF tuner: Crosley 396.

It should be noted that in the first conversion the oscillator frequency is *below* the frequency of the uhf channel. In the second conversion, the oscillator frequency is *above* the uhf i-f signal.

3. UHF CONVERTER AND TUNER

a. General. It is possible to convert pre-uhf receivers for uhf reception by adding a separately housed converter to the vhf receiver. The converter cabinet is placed on top of, or next to, the vhf receiver.

This converter is really a uhf front end with a self-contained power supply. The vhf and uhf antennas connect to specified terminals on the converter. It is possible to select either antenna by means of a switching arrangement on the converter.

This system employs a double-heterodyne principle. In the crystal mixer of the converter the local oscillator signal beats with the incoming signal to produce the first intermediate frequency that is the frequency of either Channel 5 or 6. This output is then coupled to the antenna input of the vhf receiver tuned to Channel 5 or 6, respectively. The vhf receiver then operates in its normal fashion to reproduce the picture and sound.

On some later models of receivers the manufacturers, anticipating the lifting of the uhf freeze, made provision for housing a uhf converter or tuner on the TV chassis. Power is supplied by the receiver. In this type of arrangement a switch, associated with or actually on the vhf selector, sets the receiver for uhf operation. The manufacturer supplies detailed instructions for making this conversion. Operation of this type of converter is the same as that of the separately housed unit.

UHF operation involves new tuning techniques. At the present time some of the types of resonant circuits being used are:

(1) Shorted quarter-wave transmission-line resonators, which are either parallel or concentric line arrangements, usually circular in design, with a slider acting as the shorting bar.

(2) Capacity-loaded, shorted, quarter-wave coaxial line.

(3) Shorted rectangular transmission-line resonator, which is tuned by a variable capacitor across the open end.

(4) Butterfly tuner, involving a simultaneous change in inductance and capacitance in a mechanical assembly using a stator and a rotor, or a stack of stator and rotor sections. Circuit connections are made to the stator and not to the rotor.

(5) Cylinder tuner, using two slotted concentric

cylinders. To change frequency, the inner cylinder is rotated while the outer remains stationary. Circuit connections are made to the outer cylinder.

The difference between conventional tuning methods and those used in uhf is that the latter makes use of distributed constants (such as the distributed capacity and inductance of a line), while the former use lumped constants (such as physical capacitors and coils).

b. Shorted Quarter-Wave Concentric Transmission-Line Converter. Figure 9-9 shows an early model of the Crosley continuous uhf converter. This is a chassis-mounted device which receives the B+ and filament voltage from the receiver. V1, a 6AF4 tube, is used as the oscillator. It feeds its signal to the crystal mixer, CR1, which also receives the uhf channel signal. The difference frequency in the output of the crystal is coupled to the vhf tuner, which has been set to receive either Channel 5 or 6 (whichever is not used in the area).

The uhf antenna is connected to the uhf input terminals on the converter (CO1 in Fig. 9-9). The vhf antenna is brought to the vhf input on the converter. A 300-ohm line is used to connect the output of the converter, CA1, to the antenna input of the vhf tuner. Switch, SW1, in the vhf position throws in the vhf antenna, through CA1, to the vhf receiver. In the uhf position the output of the uhf converter is coupled to the vhf tuner, while the vhf antenna is shorted out. Also, B+ is applied to the oscillator plate.

The tuning assembly consists of three circular concentric lines, mounted on a common shaft. The lines are silvered, metallic strips embedded in an insulator. A spring-type silvered wiper travels in the track between the two strips of each line and acts as the shorting arm. Maximum line length determines minimum frequency, and vice versa. At CO1 a high-pass filter couples the channel signal to the first two lines, which resonates the mixer input to the desired frequency. These and the associated circuit cover a tuning range from 465 mc to 902 mc. The third line is used to tune the local oscillator over a range of approximately 376 mc to 820 mc.

End inductors (L2, L3, and L4) and their associated series capacitors (C3, C4, and C18) are adjustable to maintain proper tracking. Coupling capacitor, C1 and C2, is adjustable to set the bandwidth of the input circuits. Coupling from the oscillator to the mixer is accomplished by a 2.2-mmf capacitor taking energy from the low-impedance filament line.

The small values of *L* and *C* required in these circuits makes these components unconventional. Thus, a small metal strip with a bend may act as a coil (for example, L2). C3 is a ceramic form, threaded to hold

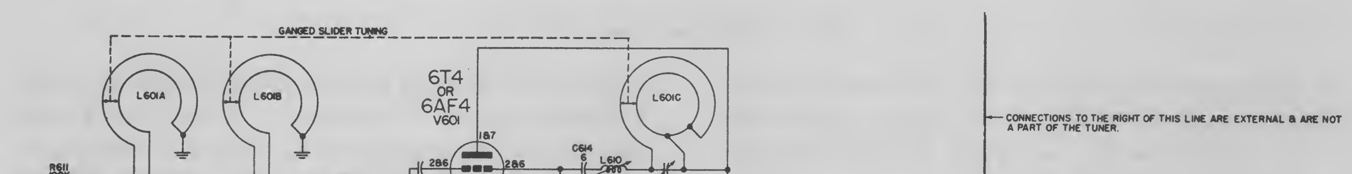


Fig. 9-10. UHF converter: Magnavox.

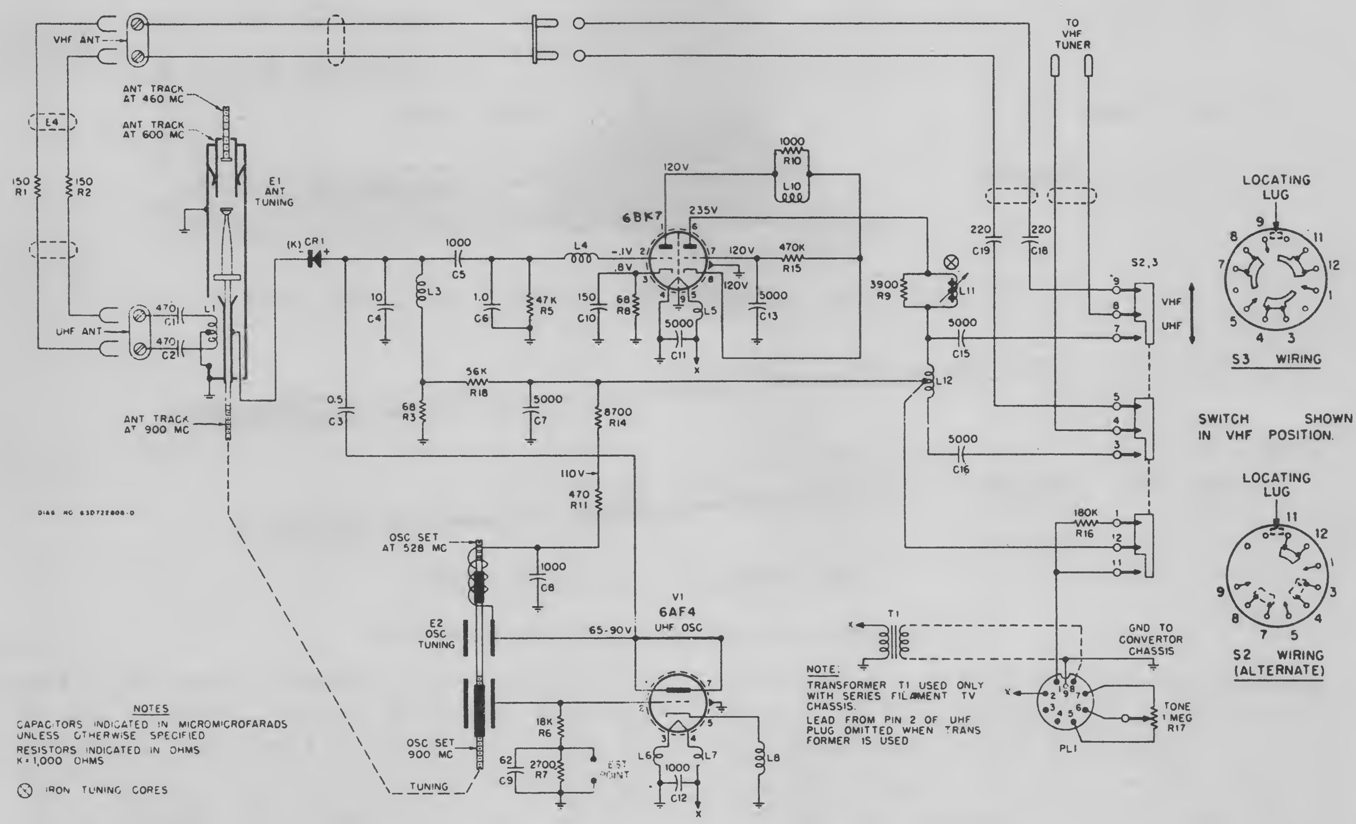


Fig. 9-11. UHF converter: Motorola 21T4AC.

a screw. The outside of this form has a metallic sleeve. The screw and sleeve form the plates of the capacitor, and the depth to which the screw is adjusted determines the amount of capacitance.

Figure 9-10 is the diagram of a Magnavox converter that also uses a shorted quarter-wave concentric line for continuous tuning over the uhf band. The diagram in Fig. 9-10 shows (in addition to a preselector, crystal mixer, and oscillator) V602, a 6BK7, used as a first i-f amplifier. This cascode amplifier takes the signal from the mixer. After amplification, the signal is coupled to the vhf tuner, which is set on Channel 5 or 6. Except for the inclusion of V602 and its tuned input and output circuits, operation of this circuit is similar to that shown in Fig. 9-9.

A concentric knob drives the main shaft and provides a 6:1 step-down ratio for ease in tuning. The uhf signal is converted to a first i-f of Channel 5 or 6 (depending on the location). The choice of conversion channels is determined by the service technician and is accomplished by connections to test points on the converter. See the note on Fig. 9-10, which explains the proper connections for using Channels 5 or 6.

Coils (L612, or L612 and L613) complete the d-c path of the crystal, X601. Crystal current, which normally should vary from 1 ma to 4 ma, can be measured by placing a milliammeter in series with TP601 or TP602 (whichever is in the circuit) and ground.

The local oscillator, V601, operates on fundamentals 76 mc to 88 mc below the selected signal in order to establish an i-f acceptable to vhf Channels 5 or 6. L610 is a ribbon lead inductor used for setting minimum oscillator inductance at the high end of the band. C615 adjusts the oscillator frequency at the low end. It is a variable (0.5-mmf to 1-mmf) ceramic trimmer. C614 and C615 are ceramic, with negative temperature coefficients to compensate for oscillator warm-up drift. Oscillator grid voltage varies from −5v to −8v over the entire range.

c. Capacity-Loaded, Shorted, Quarter-Wave Coaxial Line. Figure 9-11 is the diagram of the converter used in the Motorola 21T4AC chassis. It is an example of the use of a capacity-loaded, shorted, quarter-wave coaxial line used as the tuning element. Physically, however, the quarter-wave line is altogether different from the circular line used in the two tuners previously described.

A double-conversion system is used here. The incoming signal is preselected by the antenna tuning and is coupled to the mixer crystal, CR1. V1 is the uhf oscillator, whose signal is capacitively coupled to CR1 and beats with the incoming signal. The difference frequency is either Channel 5 or 6 and is amplified by the 6BK7, a cascode amplifier, broadly tuned to accept either Channel 5 or 6. The output

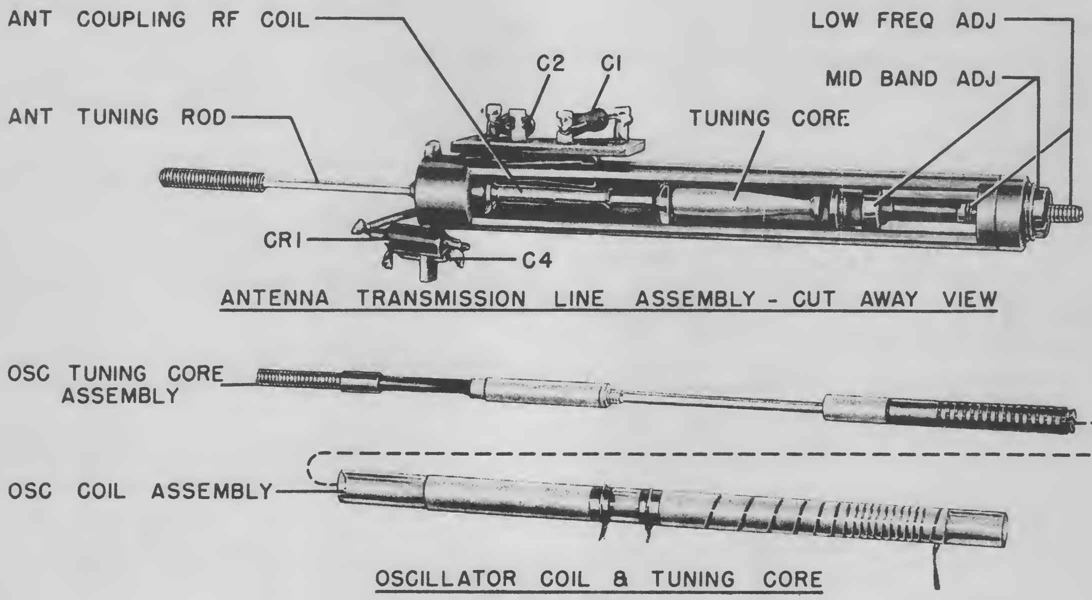


Fig. 9-12. Oscillator tuning core and coil, uhf converter: Motorola.

is then brought to the vhf tuner, set for Channel 5 or 6. Figure 9-12 is a photograph of the antenna transmission-line assembly and the oscillator coil and tuning core. Figure 9-13 is a functional diagram of the tuner, identifying the electrical characteristic with its physical component.

(1) *Antenna transmission-line assembly.* A 300-ohm balanced input receives the uhf signal, which is then loop-coupled by *L*1 into the coaxial line. The tube wall, together with the rod and core assembly (*a* and *b*, Fig. 9-13), form the inductance *La*. *Ca* is the distributed capacity between the core (*B*) and the tube wall. Frequency variation (decrease and increase) is accomplished by lengthening and shortening the line as the core moves into the tube and back. *Cb* is the capacitance formed by the core (*B*) and the capacitor tuning. *Cc* is formed by the core (*B*) and the screw adjustment (*D*). These two capacitors capacity-load the line to keep it from becoming too long. They are actually part of *Ca*. *Cc* is a tracking adjustment at the low frequency end. *Cb*, midband adjustment, is varied by threaded brushing *C*.

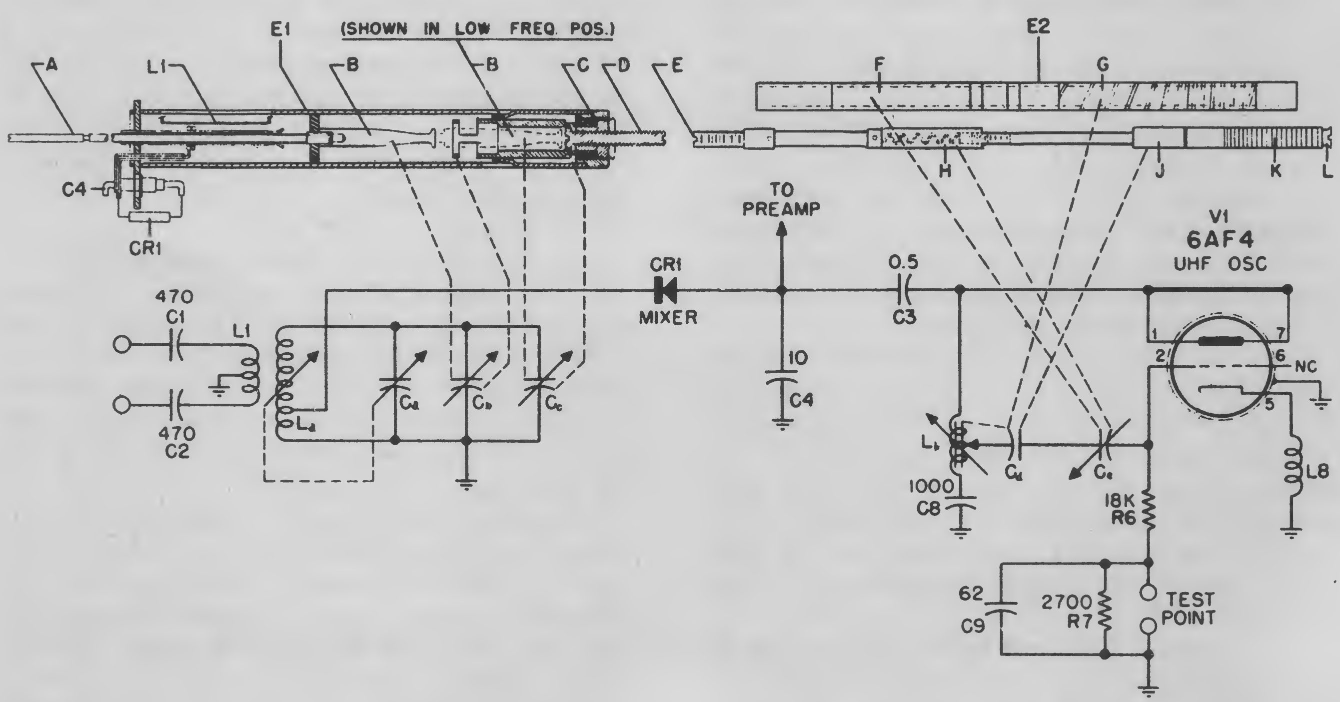


Fig. 9-13. UHF tuner functional diagram: Motorola 21T4AC chassis.

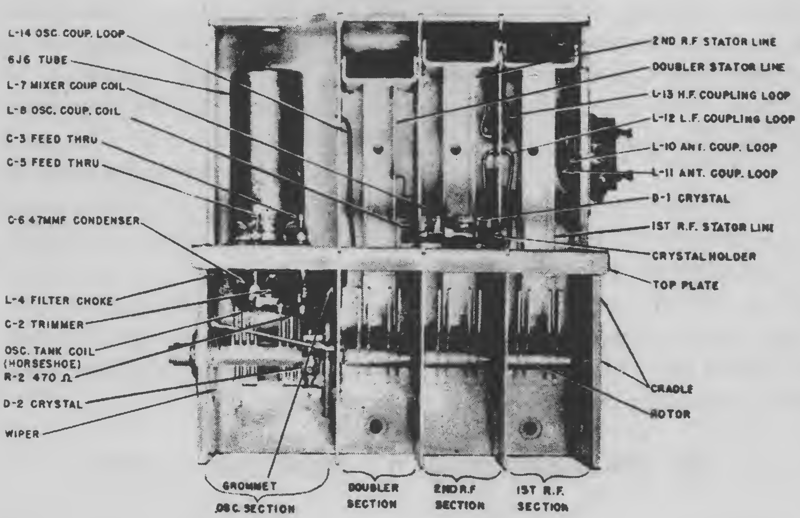


Fig. 9-14. Sylvania uhf tuner assembly.

(2) *Oscillator coil and tuning core. Lb,* the oscillator coil, consists of a metallized winding on a glass coil form (*G* in Fig. 9-13). The coil tuning core, *J,* also combines with windings to form capacitor *Cd.* Slug *K* consists of a series of copper rings which raises the resonant frequency of the unused portion of the inductance above the operating frequency to prevent "suck-outs" in the tuning range. *E* and *L* are high- and low-band alignment adjustments.

d. Rectangular Transmission-Line Resonator. This is tuned by a variable capacitor across open end. The rectangular transmission line used in the Sylvania uhf tuner is another approach. The mechanical details of the three tuned lines used in this tuner may be seen from Fig. 9-14. The lines have inner and outer conductors like a coaxial line. However, the silver-plated conductors are rectangular. Moreover, the inner conductor is hollow and is not com-

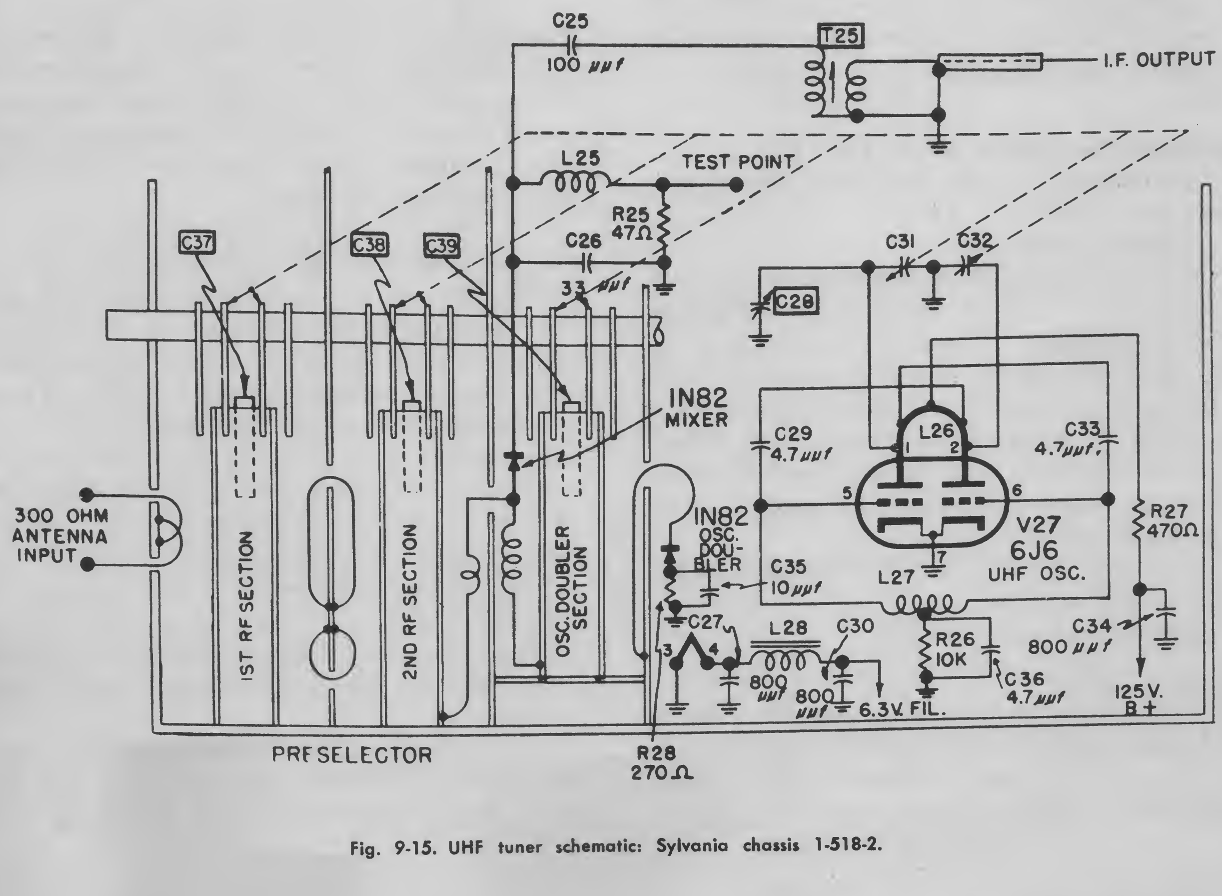


Fig. 9-15. UHF tuner schematic: Sylvania chassis 1-518-2.

pletely enclosed (top plate is missing). The top plate of the outer conductor is also removed. A variable capacitor, placed across each line, is used to vary the electrical length of the line. The three tuned lines are therefore end-tuned coaxial lines.

Refer to Fig. 9-15 for the schematic diagram of this tuner. The first and second r-f sections constitute two of the tuned lines and act as a preselector. The signal is coupled into the first r-f section by a loop. Two inductive loops are used between the first and second r-f sections. One of these loops is used for the higher uhf frequencies; the other for the lower.

A 1N82 acts as crystal mixer and is fed by the uhf signal from the preselector, and by the oscillator. A 6J6 dual triode, operating in push-pull, acts as the oscillator. A silvered horseshoe-shaped plate coil (L26 in conjunction with C31 and C32, a split stator capacitor) resonates the circuit at half the required frequency. This oscillator signal is coupled to another 1N82 crystal used as a harmonic generator. The oscillator tuned line is a high Q doubler. The final oscillator frequency lies above the incoming signal.

After mixing, the i-f signal is coupled via T25 to the i-f amplifiers of the receiver operating in the 40-mc range.

III. TROUBLESHOOTING THE FRONT-END SECTION

A. Indications of Circuit Defects

Defects in the front end affect both picture and sound, but not necessarily the raster. In this discussion we will concern ourselves with the intercarrier sound receiver. Troubles of the following nature may occur:

1. No picture, no sound, raster OK.
2. Snowy picture, sound weak or OK, raster OK.
3. Hum in picture, hum or buzz in sound or sound OK, raster OK.
4. Hum in picture, accompanied by bending of vertical lines; hum in sound or sound OK, raster OK.
5. Loss of picture detail, sound OK, raster OK.
6. Smearing of large objects, sound OK, raster OK.
7. Receiver can tune in one or several channels in a locality, but not the others.
8. Drift.

B. Instruments Required to Service Front End

The instruments required to service this section properly are:

1. Oscilloscope and probes.
2. Sweep generator covering the range of vhf channel frequencies. For uhf the vhf sweep generator may be used on harmonics, or may be converted by an external generator. As uhf sweep generators become available to the service industry, these will be best for uhf servicing. There is on the market a vhf to uhf adaptor, which converts a vhf sweep or marker to uhf.
3. Variable marker generator covering the range of r-f and i-f frequencies.
4. VTVM and/or VOM with demodulation probe.
5. Low-impedance bias box.
6. Tube tester, capacity checker.

C. Response Curves

1. Troubles Due to Improperly Aligned Tuners. These include complete loss of video and/or sound; weak, distorted, or buzz in sound; weak, snowy, smearing, loss of detail in picture, poor video sync.

2. Alignment Checks. These are made after other normal causes for a particular trouble have been investigated, or when a part that could affect the response curve has been replaced or disturbed.

3. Procedure for Checking the VHF R-F and Mixer Response Curve. For details concerning the set-up of alignment equipment, refer to Chapter 2. For matching networks, refer to chapter 10.

The instructions supplied by the receiver manufacturer should be followed as closely as possible. A general procedure will be outlined in the following paragraphs, and may be used in the absence of specific instructions.

a. Set up equipment and receiver. Use proper grounding and matching techniques. Disconnect antenna from the receiver. Connect sweep generator to the antenna terminals through a matching pad and loosely couple an unmodulated marker to the antenna terminals. Apply a fixed bias 1.5v to 3v negative to the tuner agc line.

b. Place the scope direct probe to the mixer test point through an isolation resistor of about 10,000 ohms. If there is no mixer test point, double the size of the isolation resistor (20,000 ohms) and connect it directly to the mixer grid circuit. Set channel selector to some reference channel. This may be Channel 13 or 12 on some tuners, or 13 or 6 on others. Adjust sweep generator to sweep the frequency of the selected channel, with a sweep width of 10 mc to 15 mc. Insert the corresponding picture and sound markers. Keep the marker generator output as low as possible, to avoid distortion of the response curve. However, it may be necessary to maintain maximum generator output if there is insufficient scope waveform. Refer to Fig. 9-16 for some typical response curves.

c. The ideal curve is flat-topped between the two markers, and the markers are located at points of equal and maximum amplitude on the curve. The

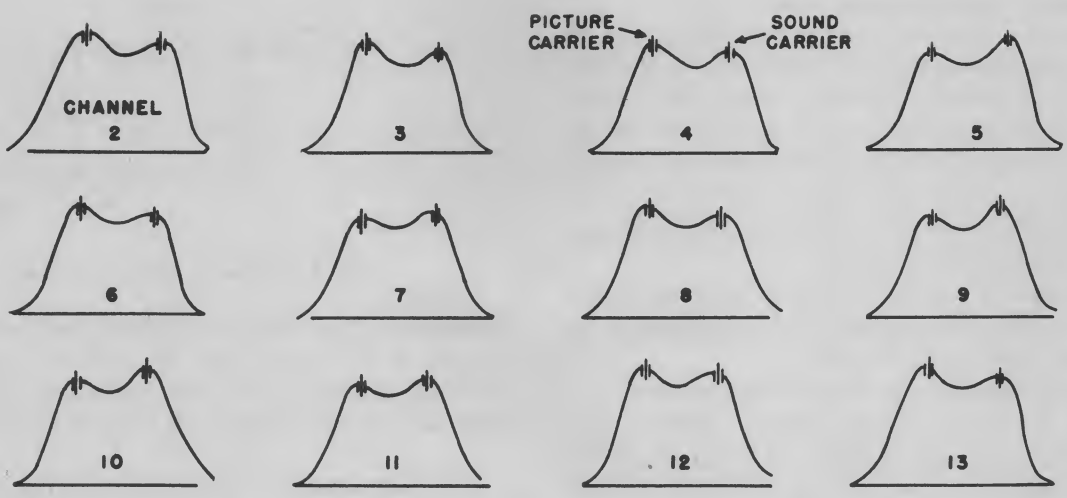


Fig. 9-16. Typical response curves for TV tuners. Courtesy *Hallicrafters.*

curve observed consists of the r-f plate, mixer grid, and antenna curves. The practical limits of the curve permit a valley of up to 30 percent between the two markers, and either marker as low as 70 percent of the maximum amplitude. Check all channels and refer to tuner alignment instructions (Chapter 10) if overall curve does not come up to specifications.

D. Front-end Control Adjustments

The troubleshooting process includes adjustment of controls associated with the affected section. As a general rule, alignment adjustments should not be a haphazard process and should not be attempted without proper alignment equipment. There are, however, certain exceptions. These are listed below.

1. Local Oscillator Adjustment. This can be accomplished with alignment equipment or by the use of the signal transmitted by a station. This section will discuss only the method that utilizes the transmitter signal.

2. Turret Tuner. Adjustments of these components are rather simple. The turret is switched to the particular channel to be adjusted and the fine-tuning control is set approximately to the center of its range. This setting of the fine tuner should coincide for all the channels, in order to minimize fine-tuning adjustments when switching from channel to channel. The proper type of adjustment tool (usually a screwdriver with a thin, nonmetallic or insulated handle) is used to tune the oscillator adjustment for the best combination of sound and picture. On the intercarrier type of receiver it may be necessary to sacrifice either some picture quality or sound output on the weaker channels in order to obtain the best over-all results. Care must be exercised to prevent the adjustment screw from falling into the coil. A master oscillator trimmer is usually provided for the purpose of shifting the tuning range of all the adjustments at once. This can be used to simplify adjustment when the oscillator tube has been replaced or when certain channels cannot be brought into range.

3. Switch Wafer Tuners. These require a little more attention. The type of coil arrangement must be determined first. If individual coils are used, then the procedure is the same as for the turret tuner. When the coils are wired in a series arrangement (see Fig. 9-3, switch S1, section 1), the adjustment method differs. In Fig. 9-3 adjustment of higher channels affects lower channels, within the range of channel 13 to Channel 7 and of Channel 6 to Channel 2. For practical purposes the adjustment of Channel 13 affects Channels 13 through 7, and adjustment of Channel 6 affects Channels 6 through 2. In this particular tuner, high channels are adjusted by moving the coils up or down, while low channels are adjusted by compressing or spreading the coils.

4. The Continuous Tuner. This component does not require individual oscillator adjustment since the oscillator is tuned by the main selector control. When a station on one end of a band (say, Channels 2, 6, 7 or 13) cannot be properly tuned in, then the oscillator adjustment must be reset. In Fig. 9-4 the high-band oscillator adjustments are C28 and L10, while the low-band adjustments are C31 and L11.

Additional adjustments on the tuner may be made without alignment equipment, but only when specifically recommended as a field expedient by a manufacturer. Thus, if only one channel is being received in a weak signal area, the r-f section may be peaked for that particular channel. This is an experimental procedure and may not work. In which case, the adjustments must be returned to their original setting. This process requires that the original adjustment position be taken by accurate measurement and carefully noted.

E. Preliminary Troubleshooting Steps

The general troubleshooting procedure given in Chapter 1 also applies to this section. Troubleshooting the front end section should, however, be limited at first to tube replacement and accessible voltage and resistance measurements. The next step should be an attempt to isolate the tuner as the cause of the defect. This precaution is necessary to avoid any unnecessary handling of the tuner.

1. Try different channels. If it is possible to get reception on only one channel, the trouble may be in either the tuner or the antenna.
2. Check antenna or use a substitute antenna.
3. Check for snow content in the picture. The presence of snow usually indicates that all the video stages following the tuner are operating. If snow is present, but it is impossible to get reception, the antenna, the tuner, or the first video i-f may be defective. Therefore, as an added precaution, check the first video i-f.
4. Check for sound. If the sound is normal or somewhat less than normal and the screen has no indications of noise or picture, then the tuner is probably operating. The front end should be investigated, however, if there is sound and snow but no picture.

If the sound is tunable by the fine-tuning control, the oscillator is operating.

5. Try changing the front-end tubes.
6. Make a physical examination of spring contacts in the switching arrangement. Clean all dirty contacts with some suitable preparation. Lubricate contacts with pure mineral oil.

F. Servicing Procedure

1. No Picture, No Sound, Raster Present

a. Tuner Isolation—External Electrical Checks. Internal tuner servicing should be undertaken only after isolation of the defect to the tuner has been established. This includes the following:

Checking in the video section for composite waveform with a demodulator probe and scope. It is often possible to trace the signal from the video detector, through the i-f's, right up to the tuner. A channel known to be transmitting at the time should be selected. If a video signal is present at any point (using this procedure), it indicates that the tuner is passing a signal. If there is no indication on the scope, the fine tuner should be varied, to be certain that the station is tuned in.

In home servicing, a 50-ma meter (such as is used in the 20,000 ohms/volt VOM's) can be used in conjunction with a sensitive demodulator probe (see Fig. 9-17) for signal-tracing the i-f stages. The 50-ma range is used as a voltmeter range on weak signals. An in-

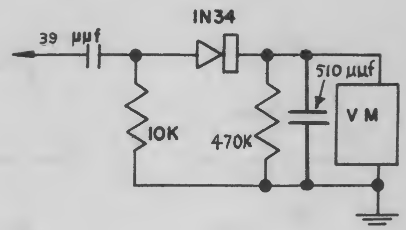


Fig. 9-17. Detector probe for voltmeter.

dication of the presence of signal can usually be obtained at the grid of the first video i-f tube with a normal operating front end. Again, it may be necessary to vary the fine-tuning control to get an indication.

A signal generator and scope will conclusively isolate the tuner or its voltage sources (B+, filament, or agc) as the defect. This test may be made either before any of the preceding tests or as a final check. The signal generator and tuner are tuned to the same frequency. The generator output is connected to the tuner antenna terminals. The scope direct probe is connected to the mixer grid test point to check the circuit up to the mixer grid. The scope demodulation probe may be connected at the output of the tuner or to the grid of the second i-f tube. When connected to the tuner output, only the tuner is under test. When connected to the grid of the second i-f tube, the additional i-f stage is under test. This latter method is used when the generator or scope requires the additional gain for an indication.

Any or all of the preceding tests will give information about the condition of the tuner. In addition to these (or if these tests cannot be made), voltage checks will help to isolate the trouble to the front end.

Voltage Checks

Plate and *screen* voltages in tuner.

Mixer grid voltage. This voltage results from oscillator injection and is an indication of operation of both the oscillator and the mixer grid circuits. This voltage is variable, and depends on many factors, such as frequency, oscillator output, and design. The negative voltage developed at this point should be approximately 2v on the high channels and 3v on the low channels. The range here is usually from −1.5 to −7v. A test point for checking this voltage is sometimes included on a tuner (see TP1, Fig. 9-2; and test point, Fig. 9-3). Where this is not provided, a fine piece of wire wrapped around a tube pin or a socket adaptor may be used for voltage checks.

Oscillator voltage. This voltage may be checked directly by connecting a 20,000 ohms/volt volt-

meter or VTVM in series with an isolation resistor to the oscillator grid. This resistor should be at least 20,000 ohms, and the voltmeter readings should be from −1v to −6v on the high channels to −1.5v to −12v on the low channels. A cathode resistor may be incorporated in the oscillator circuit, with the grid resistor returned to cathode (6U8 triode in Fig. 9-5). In this case a positive voltage will appear on the oscillator grid with respect to ground. However, the voltage with respect to cathode should be negative.

Voltage on the plate of the input and cathode and grid of the output triodes of the direct coupled section of an r-f cascode amplifier (see Figs. 9-2, 9-3, 9-4, and 9-5). This must be a dynamic check with the tube in the circuit, since voltages at these points depend on the operation of both triode sections. A continuity check may be made from the common plate to cathode circuit. This should show a very low resistance between each other and an infinite resistance to ground. The second grid will have positive voltage applied to it from an external voltage divider source, except for Fig. 9-4, where the Raytheon tuner has the grid tied to the cathode through choke (L2) and derives its voltage from the cathode.

b. Internal Tuner Servicing. After all the checks previously described have been made and trouble is still indicated, the tuner is opened for further checks. Covers, as well as removable shields and inspection plates, are taken off. Spots of solder for good grounding may be found on these. They should be unsoldered, but must be resoldered after the repair is completed. Occasionally, it is necessary to remove the tuner from the chassis for internal servicing. When this is the case, the tuner leads should be carefully removed and short extension leads used for dynamic testing.

A physical inspection is made for obvious defects. This includes burned or overloaded components, or shorts created by components touching, tarnished or defective contacts, mechanical breakage, and poorly soldered contacts. With rough handling, a tuner frame may become distorted. This can be checked by noting the position of, and/or the side pressure exerted by, contacts. Where this occurs, a gradual pressure may be exerted to bring the frame back into shape. Resistance measurements are made of suspected components. An open coil is easily located in this manner. Most coils used in the tuner, however, have negligible resistance and therefore cannot be checked for shorts.

A dynamic test is performed next. The receiver is turned on and a local channel is tuned in. Then voltage measurements which could not be completed outside the tuner are made. On a turret tuner either a few, or all but one set of, channel strips may be removed for servicing convenience. Thus, a set of channel strips on an operating channel is left engaged with the stationary contacts while enough of the remaining channel strips are removed to facilitate servicing.

If the previous checks do not localize the defects, a systematic signal-tracing procedure is used next.

An r-f signal voltage of the proper frequency, from a modulated signal generator or from an antenna, may be coupled into the plate of the r-f amplifier. The r-f tube is removed from its socket and a capacitor is used to couple the signal into the circuit. If signal comes through the remainder of the circuit, the r-f amplifier must be investigated. Otherwise, a modulated i-f signal is fed to the grid of the mixer, and either the screen of the CRT or a scope connected to the detector is observed for indications of the modulation. If the i-f signal gets through, it is possible that the oscillator frequency is too far off to bring in a channel.

A substitute oscillator signal can be fed into the mixer when such is the case. It may be necessary to remove the coupling of the receiver oscillator from the mixer circuit. The signal generator is unmodulated and set at the channel oscillator frequency. A small capacitor (about 5 mmf to 12 mmf) is used for coupling, and the generator frequency and the output is varied. If it is now possible to bring in a station, then the local oscillator is at fault.

2. Weak Reception. This often may be caused by the tuner. When the trouble is located in the r-f amplifier, the weak reception will generally be accompanied by snow. The general procedure indicated under "No Sound, No Picture" is followed at this point. In addition, quality of performance must be considered. Therefore, after the preliminary checks, r-f sweep generator and scope present the best method of making a performance test. Using a known good tuner, response curves are compared as to output, bandwidth, and amplitude with a given input signal. A fast, though not conclusive, test of the r-f stage can be made by capacitively coupling grid to plate of the r-f tube or antenna to plate, with the r-f tube out of the receiver in both cases. A definite improvement indicates a weak r-f stage.

3. Noisy or Intermittent Tuner. Noisy or intermittent tuner operation will often require mechanical inspection. Any bad contact, such as at a switch point, solder connection, loose element in a tube, or defective trimmer, can be the source of this trouble. The receiver should be put into operation and all suspected contacts should be probed with an insulated tool. This inspection should include a gentle tapping and the application of slight pressures on com-

ponent parts. Suspected solder connections should be resoldered and mounting hardware tightened. Locknuts on adjustments and shields should be tight. At no time should adjustments or coil positions be disturbed.

4. UHF Tuner, Converter, and Strips

a. The servicing procedure for uhf falls into the same category as the previous tuner discussion. Procedures involving signal generators require instruments capable of generating signals in the uhf spectrum. Under tuner isolation, two additional tests are available. These consist of:

(1) *Checking the vhf tuner.* The uhf system should not be investigated until the set is operating normally on vhf. For uhf reception the front end and antenna are the only sections modified. The remainder of the receiver operates exactly as with vhf.

(2) *Substitution of a known good uhf converter.* The circuit is arranged to permit the test converter to receive signal from the uhf antenna. The converter then converts the uhf information to vhf frequency, and the receiver is tuned to the proper vhf frequencies. If the receiver operation is improved on uhf, then the uhf tuner, converter, or strips are investigated. Occasionally, improvement may be noted in reference to interference rejection. This does not always indicate a defect in the receiver. The characteristics of a particular conversion system may create a combination of frequencies that makes it more susceptible to a given local interference.

b. Crystal Operation Tests. In addition to normal voltage and resistance checks, the uhf tuner may be tested for crystal operation. This includes:

(1) *Crystal current.* Check points are provided on some uhf tuners for this purpose.

(2) *Crystal forward and backward resistance.* Crystals normally used as mixer and harmonic generators have different resistance values from those used in detector circuits. A back-to-front resistance check should indicate a ratio of larger than 10, or the crystal is considered bad.

(3) *Crystal substitution with a known good crystal.* Polarity should be maintained according to manufacturer's data. Other check points provided on some uhf tuners include:

(4) *Oscillator grid current.*

(5) *Oscillator plate voltage.*

G. Preventive Maintenance and Parts Replacement

1. Tools. Tools used for tuner repair must be small and thin with long handles, to allow the technician to perform needed repairs within the tuner. Special tools that permit fine work in close quarters should be obtained or constructed; these include:

a. Ground-down cutters.

b. Hooked pick and straight pick.

c. Slotted screwdriver.

d. Thin long-nose pliers.

e. Long tweezers.

f. Long, thin soldering tip on soldering gun.

2. Repair Practices. The technician should always be aware that the tuner is an exceptionally delicate mechanism.

a. Contacts should be clean and firm with the correct amount of pressure on opposing points.

b. Soldering should be accomplished quickly and with a minimum amount of heat. This is of special importance when soldering to feed-through capacitors.

c. Parts replacement must be exact, with temperature ratings meeting manufacturer's specifications in oscillator circuits. Oscillator warm-up drift results when the proper temperature-compensating capacitor is not used.

d. Tube replacement should be with the same type. Alignment curves change excessively when using equivalent types. If equivalent types are used, the alignment should be checked.

e. Tuner replacement, when made with a different type, should make provision for the different requirements. The cascode tuner requires higher B+ voltage on the r-f tube. The maximum gain for the agc controlled triode is obtained with approximately 0.5v negative, and its gain characteristics do not vary the same as a pentode with the same bias voltage. Minimum bias requirements should therefore be maintained.

CHAPTER 10. ALIGNMENT

I. ALIGNMENT REQUIREMENTS

A. Introduction

1. General. Essentially, the procedure in alignment is not so difficult as the problem of deciding when it is necessary. The servicing techniques of the technician depend more on his approach toward the problem of alignment than on his repair facilities. This is explainable if we categorize the three types of technicians prevalent today.

a. The Diddler. This man is a screwdriver mechanic, whose approach to every servicing problem is, "There must be something wrong with the alignment." I-F, front end, sound adjustments — all are at his mercy. This kind of botcher can create more trouble in two minutes than you can correct in two days. Happily, this species is becoming extinct.

b. The Caspar Milquetoast. Although he once read that one in every hundred sets that come in for servicing may need realignment, his rule is, "Never touch alignment." Percentage-wise, however, this type is much safer than the *Diddler.* But he cannot handle satisfactorily those receivers that may need realignment. He therefore cannot give 100 percent customer satisfaction.

c. The Competent Technician. This man accepts the fact that few sets need realignment. However, he does not avoid realignment when it is required. He follows the few common sense rules to be observed for proper alignment technique. These are:

(1) Do not attempt realignment unless you are certain that it is necessary for a satisfactory service job.

(2) *Use proper equipment.* This is an absolute *must.* TV sets are much more complex than ordinary radios and cannot be aligned by sight and sound indications.

(3) *Understand the alignment process* completely for a particular receiver, before starting.

(4) Follow the manufacturer's detailed instructions.

2. When Realignment Is Needed. Realignment may be needed when frequency critical components in tuned circuits have been replaced or have been thrown out of adjustment. For example, replacement of i-f coils may require alignment touch-up. Similarly, replacement of the local oscillator tube or replacement of an entire section (such as the front end or an i-f strip) may require realignment. Sometimes, the resonant characteristics of circuits may change due to change in value of components. This is not to be confused with the normal drift that may take place while a receiver is warming up. Some rules to determine whether or not alignment is *needed* are:

a. If picture quality is good but the picture is weak, trouble is probably *not* alignment.

b. If picture quality is poor and the fine-tuning control has no effect on quality, trouble is probably *not* alignment. In this case, check the video amplifier (s).

c. If picture quality is poor and the fine-tuning control has a decided effect on quality, realignment *may* be needed.

d. If some channels can be received properly but others cannot, and the antenna is not the source of trouble, slight oscillator touch-up may be required.

e. If the response curve of a section differs from manufacturer's information, need for realignment is indicated.

3. Receiver Checks before Realignment

a. Take the response curves of the suspected sections to determine which one appears to require realignment.

b. Be sure that all voltages in the suspected section are correct. Frequently, a defective component, such as a leaky or shorted bypass capacitor in the screen of an i-f tube, a shorted coil, or a defective tube, may give effects similar to improper alignment. Voltage checks will usually lead to the source of trouble.

4. Instruments Required. The technician must have the proper equipment for adequate alignment. He should know the performance characteristics and reliability of his instruments. For a description of the equipment listed below, see Chapter 2.

a. Sweep Generator. This should provide frequency coverage over the i-f and r-f ranges of the receiver. It should have an output variable up to 0.1v. The sweep width should be adjustable up to about 12 mc. The instrument must also have a flat output over the range it is sweeping.

b. Marker Generator. The marker generator must have facilities for frequency calibration to crystal accuracy. It must cover the range of i-f and r-f frequencies of a TV receiver.

c. Oscilloscope with Direct and Crystal Detector Probes. For desirable characteristics, refer to Chapter 2.

d. VTVM with Direct and Detector Probes.

e. Low-Impedance Bias Box.

f. Special Alignment Tools. These should include the types with both nonmetallic and metallic handles. Alignment kits are available which incorpor-

ate most of the special tools specified by manufacturers. Otherwise, special tools may be secured from the receiver manufacturer.

5. SECTIONS OF RECEIVER WHICH MAY BE ALIGNED. In this category are included:

a. The tuner.

b. The video i-f's and associated traps.

c. The sound i-f's and associated traps.

B. Setting up Equipment for Alignment or for Observing Response Curves

1. Refer to Chapters 2, 6 and 7 for a review of the principles of setting up the equipment for taking response curves.
2. Particular attention should be paid to proper bonding and grounding of the receiver and all instruments. All leads should be shielded, except ground leads. Copper braid is recommended for ground connections.
3. Generator output and scope input leads should be as far apart as possible.
4. Place a 10,000- to 47,000-ohm resistor in series with direct probe of scope or d-c lead of the voltmeter when these are used as indicators. Keep this isolating resistor as close to probe tip as possible.
5. Place a 0.001-mf to 0.01-mf capacitor across vertical input of the scope to sharpen marker pips.
6. Keep generator and indicator leads away from i-f cans, coils, or other resonant circuit components.
7. *Disable high voltage* to insure greater safety and to reduce possibility of horizontal sweep radiation, which may be observed as spikes on the response curve. This may be accomplished by removing the high-voltage fuse if one is used. Otherwise, remove the horizontal oscillator and output tube; or open the oscillator B+ supply and bias the horizontal output tube to cut-off. If a negative supply for biasing the grid of the amplifier is not available, open the screen grid circuit in the horizontal output tube and remove the plate cap from the output tube.
8. Maintain proper bias, using bias box, as specified by manufacturer.
9. Permit all equipment and receiver to *warm up* for about 15 minutes before alignment.
10. In front end alignment be certain that an impedance-matching network is used to match the generator to the receiver. See "Front End Alignment" for details.

C. Order of Alignment

A survey of alignment procedures of late receiver models reveals that there are many different methods of alignment employed, each requiring a specific order of alignment. The manufacturer's instructions should be followed.

II. ALIGNMENT TECHNIQUES

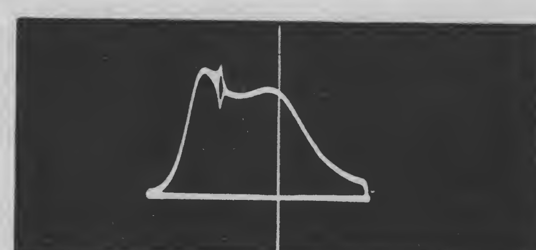
A. General Techniques

1. MARKING THE RESPONSE CURVE. The response curve of a tuned circuit is obtained by injecting the output of a sweep generator into the circuit and observing the detected response on an oscilloscope. By coupling the signal of a marker generator to the circuit under test, a pip appears on the response curve at the frequency of the marker generator. This is a beat note between the marker and sweep generator signals. The marker generator must be coupled loosely to the circuit as previously described, and its output must be kept low.

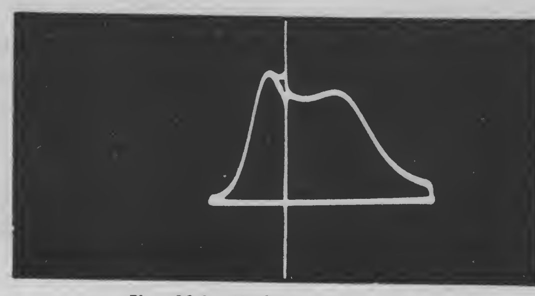
If the response curve is shifted horizontally on the scope by adjustment of the scope centering control, until the marker pip coincides with the vertical grid line on the graph of the oscilloscope, the marker generator may be turned off, or its frequency can be shifted. The vertical graph line continues to mark the curve at the original marker frequency as long as the sweep generator and oscilloscope controls are not varied. The only instrument controls that may be adjusted without displacing the marker line are the scope gain and the generator attenuator controls. The marker generator may then be used to mark another part of the trace, which may be similarly identified during the alignment process (see Fig. 10-1).

2. CHECKING FOR CURVE DISTORTION

a. Loading. Excessive generator output will cause overloading and consequent flattening of the



A



B

Fig. 10-1. Marking sweep curves.

response curve. Very low generator output may cause peaking. The output of the generator must therefore be maintained at a proper level during the alignment process. It is good practice to continue reducing the generator output as more circuits are brought into alignment.

To check whether there is curve distortion due to signal level of either sweep or marker generator, the technician should vary the generator output control up and down. If the generator level was properly maintained, there will be little or no change in the shape of the response curve for small adjustments of generator level in either direction. If there is a change in shape (other than amplitude), then the generator signal level has distorted the curve. Figure 10-2 (B) shows the three curves closest to base line affected very little by change in signal amplitude. The fourth curve, with greatest input, displays a decided change in shape.

Excessive coupling of marker generator may cause loading of the circuit. This can be detected by completely removing the marker generator lead from the circuit. If the response curve is altered, looser marker coupling is required. Figure 10-2 (A) and (B) illustrates the overload conditions just described.

b. Hum. If the sweep generator has retrace blanking, the *zero* reference line should be observed for evidence of hum. Absence of hum will be evidenced by a perfectly flat base line. If there is hum, it will be seen on the base line. Figure 10-3 (A) illustrates this condition.

If there is no retrace blanking feature on the sweep generator, it should be possible to superimpose the forward and reverse trace on the scope by proper adjustment of the phasing control. If the curves cannot be superimposed, it is evidence of hum. Figure 10-3 (B) illustrates this condition.

The source of excessive hum should be determined and corrected before proceeding.

3. Alignment of Traps. Trap adjustment requires high generator output. Traps are tuned for minimum indication. Trap frequencies must be set with crystal accuracy.

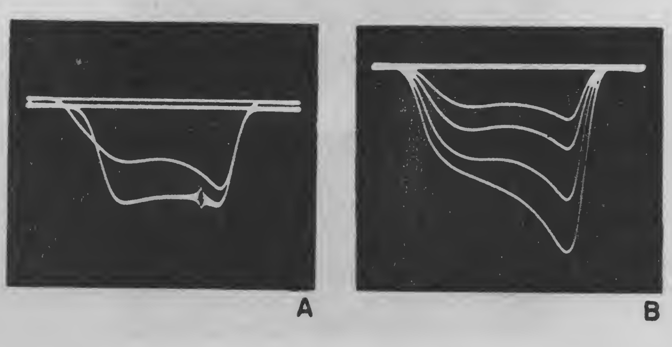


Fig. 10-2. Distortion of i-f sweep curves.

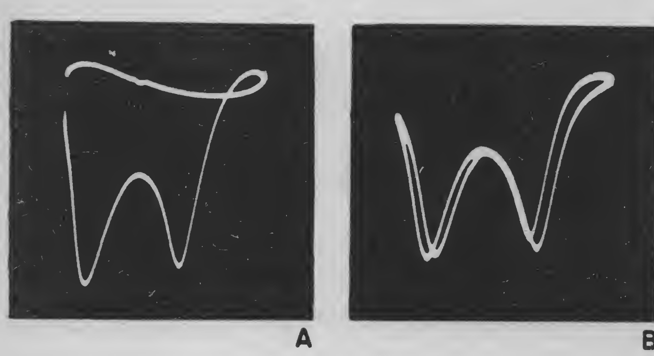


Fig. 10-3. Sweep curves with hum present.

a. C-W Signal Generator and VTVM. A trap can be aligned by setting the c-w generator to the correct frequency and injecting its signal at maximum generator output. A voltmeter is used as an indicator, at the output of the detected trap signal (for example, output of video detector). If the trap signal is not detected (for example, 4.5-mc trap in plate of video amplifier), a detector probe must be used with the voltmeter (see Fig. 10-4).

b. A-M Signal Generator and Scope. Another method for trap alignment involves the use of an amplitude-modulated signal generator and an oscilloscope. Percentage of modulation should be high. The oscilloscope replaces the VTVM and acts as a high-gain indicator. As in the VTVM method, the trap signal must be demodulated before it can be seen on the oscilloscope. (The modulating signal is actually seen on the oscilloscope). Therefore, the direct probe of a scope may be used if the trap signal is taken from the output of the video detector. Otherwise, the scope demodulator probe must be used. The trap is tuned for minimum output.

c. Sweep Generator and Scope. Trap alignment, using a sweep generator and scope, can also be accomplished. An amplitude-modulated marker can be used to advantage. Figure 10-5 (A) shows the response curve with a-m marker before trap adjustment. Figure 10-5 (B) shows the effect of trap adjustment on the response curve. The modulating envelope reduces to a minimum or disappears when the trap is properly adjusted.

4. Use of Bias Box. Tuner and video i-f alignment requires the use of a low-impedance bias box. This is usually placed across the agc bus to supply negative bias to the grids of the controlled tubes. Manufacturer's instructions should be followed for bias level and actual hookup.

5. Setting of Controls to Manufacturer's Specifications. Manufacturer's specifications should be followed in setting of receiver controls, such as contrast, agc, fringe, and others.

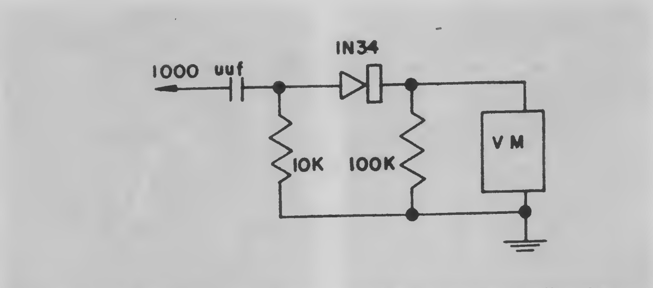


Fig. 10-4. Detector probe for voltmeter. Courtesy Hallicrafters.

6. Comparison of Response Curves with Manufacturer's Data. Response data are not always photographs, but may sometimes be drawings of the idealized response curve. Moreover, many manufacturers specify tolerance for tilt, and for amplitude of the curve at critical marker settings. The technician should be guilded by these facts in the alignment process.

B. Video I-F Amplifier Alignment Techniques

1. Preventing Front-End Interference or Distortion of Response Curve. In aligning the video i-f's or observing their response curves, it is necessary to prevent signal pick-up interference by the front end. This may be done by disabling the local oscillator. A simple way to do this for some switch-type tuners is to set the selector switch between channels. Another way is to tune the receiver to an off-channel that gives the least interference. This can also be done by replacing the mixer-oscillator tube with a dummy tube whose oscillator plate pin has been clipped. Another method to minimize interference is to remove the r-f amplifier.

2. Methods of Alignment. Essentially there are two different methods used in the alignment of this section.

a. C-W Generator and VTVM. The unmodulated output of an accurate signal generator (the marker generator may be used) is applied to the i-f's, which are then peaked at frequencies specified by the manufacturer. A VTVM is used an an indicator. The VTVM is usually placed in the output of the video detector, where it measures the rectified i-f signal on the d-c scale. Trap circuits are aligned at the proper frequencies for minimum indication on the meter. Signal generator injection may be into the grid of the mixer, where it is kept during the entire process, or the generator may be shifted to different injection points.

When this is completed, a sweep generator, set to the middle of the i-f range and sweeping approximately 10 mc, is properly injected into the mixer stage. The response curve resulting from the stagger-tuning process is accurately marked by a variable marker generator and observed on a scope. The adjustments previously made are now touched up to secure the proper response specified by the manufacturer. The manufacturer usually indicates which parts of the curve are most affected by specific adjustments.

b. Sweep Generator and Oscilloscope. The frequency-modulated output of a sweep generator, set to the middle of the i-f range and sweeping about 10 mc, is applied to the i-f's. A marker generator signal is coupled in and the response, usually taken from the output of the video detector, is observed on the oscilloscope. The i-f's are then adjusted for proper shape and amplitude, and for proper positioning of the markers on the curve, as indicated in the manufacturer's alignment instructions.

Again, sweep generator injection may be into the grid of the mixer or elsewhere in the i-f stages.

Some manufacturers specify the use of a detector probe with the oscilloscope. With this probe, the response of individual stages may be observed and these stages aligned, one by one. An over-all response is then taken for touch-up.

Stagger-tuning may also be accomplished using a sweep generator and scope. A marker signal, set at the frequency to which a particular i-f coil is to be peaked, marks the response curve. The i-f stage is then peaked for maximum response at this frequency, regardless of the shape of the rest of the response curve. Of course, as in the method employing a signal generator and VTVM, over-all touch-up of the curve is necessary at the completion of the peaking adjustments.

3. Oscillation. Occasionally, i-f amplifiers break into oscillation during alignment. This is readily

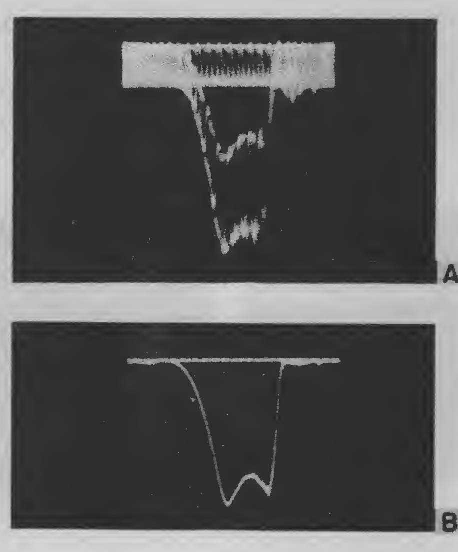


Fig. 10-5. A-M marking of traps.

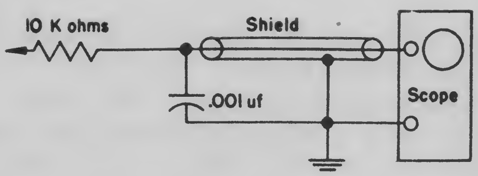


Fig. 10-6. Oscilloscope isolation network. *Courtesy Hallicrafters.*

identified by a sudden large increase in signal reading, as shown on the scope or the VTVM. For example, when oscillation sets in, a VTVM indication can jump from –5v to –50v, or even higher. Moreover, reducing the generator output some has no effect on i-f stage output.

Oscillation may be caused by introduction of the signal generator or indicator leads into the circuit. Use of shielded leads, separated from each other as far as possible, may help to eliminate oscillation. The use of a decoupling or isolating network at the probe tip of the VTVM or oscilloscope may eliminate the effects of oscillation. This decoupling network is usually specified in the alignment instructions and consists of a resistor (about 10K to 47K) in series with the probe tip and a 0.01-mf capacitor from the probe tip to ground (see Fig. 10-6).

Oscillation may also be due to the fact that two or more i-f stages are tuned to, or close to, the same frequency. An oscillating cycle is set up which may involve these stages alone or together with the remaining i-f stages. One method of eliminating this problem is to align the i-f stages, one at a time, and disable or load down the other i-f's. Thus, it is possible to remove an i-f tube whose circuits are not being adjusted at the time, and replace it with a 0.005-mf capacitor connected from grid to plate. This maintains the signal path but eliminates the gain of this stage, and may eliminate oscillation.

Another method is to detune offending stages while aligning another stage. The detuned stages must subsequently be realigned.

Still another method frequently used involves the alignment of the i-f amplifier closest to the video detector first, shorting out the grids of preceding stages with a 0.005-mf ceramic capacitor. For example, say the plate circuit of the fourth i-f is being aligned, and the generator is fed to the grid of the fourth i-f while the grid of the third i-f is r-f shorted as indicated. After the fourth i-f plate circuit is adjusted, the short is removed from the grid of the third i-f and placed in the grid of the second i-f. The generator is then moved to the grid of the third i-f and the third i-f plate circuit and fourth i-f grid circuits are adjusted. This process continues until all the i-f's are aligned properly.

4. Spurious Markers. These may be due to interference from other signal sources in the lab or shop. They may also arise from beat notes of harmonics of the generator and local oscillator. Identification of these undesired markers may be very difficult. Any one or all the methods outlined below may be used to help identify the desired marker.

a. Reduce the signal level or coupling of the marker generator. This may eliminate the undesired markers but leave the desired one.

b. Shift the marker generator frequency. Marker indications that remain stationary are spurious.

c. Vary the sweep generator frequency. A true marker will move with the curve, as the sweep generator frequency is varied, and will maintain a fixed position relative to the curve.

d. Vary the marker generator through the range of the response curve. A spurious marker will move faster or slower than the desired marker.

e. Shut off the marker generator. Spurious markers will remain.

f. When sweeping and marking the video i-f's, vary the fine-tuning control. Spurious markers will move along the curve. The desired marker will not.

It is essential to identify spurious markers to insure proper frequency tracking of the response curve.

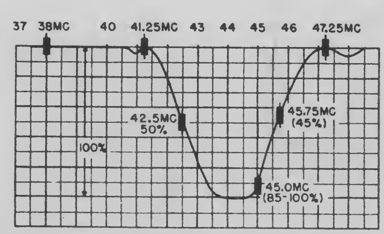
5. Typical Video I-F Response Curve in Intercarrier Sound Receiver. Figure 10-7 is a typical i-f response curve of a receiver using intercarrier sound in the 40-mc i-f range. The video i-f carrier is 45.75 mc, and the sound i-f carrier is 41.25 mc.

The video carrier is usually set at 40 to 60 percent of the amplitude of the i-f response curve. The manufacturer (GE) has specified this carrier at the 45 percent point.

The sound carrier is usually located about 5 percent up on the curve. Note its location (41.25 mc) on the curve.

The 47.25-mc marker identifies the lower adjacent-channel sound trap. For reference purposes the manufacturer has specified that the peak of the curve represents 100 percent response amplitude. Note that there is a 15 percent tolerance set for the 45-mc marker, whose placement may fall to between 85 and 100 percent.

The bandwidth at the 50 percent mark is approximately 3.25 mc. This is the difference between 45.75 mc and 42.5 mc.



Peak of curve = 100% Adjust T151 and T104 for *flat* peak. Adjust L157 to correct for any "Tilt." 45.0 mc may fall between limits of 85–100%

Fig. 10-7. Video i-f response curve: GE 21T1.

C. Front End Alignment

1. MATCHING IMPEDANCE OF SWEEP GENERATORS TO RECEIVER. The accepted standard today for the input impedance of a TV receiver is 300 ohms, balanced to ground.

Sweep generator output impedance varies from model to model. Moreover, the output of the generator may be balanced or unbalanced. Therefore, matching pads made from carbon resistors must be used to match the generator output to the receiver input. By this means, line reflections due to impedance mismatch, which may distort the response curve, are minimized.

a. Matching Pads — Unbalanced Generator Output. For generators with unbalanced output, whose output impedance Z_0 is less than the 300-ohm input impedance of the receiver, the matching pad shown in Fig. 10-8 (A) may be used.

Practical values of R_0 and R_1 for different values of Z_0 are shown below. Z_0, R_0, and R_1 are all given in ohms.

Z_0	R_0	R_1
50	56	120
72	82	110
92	110	110

b. Matching Pads — Balanced Generator Output. TV sweep generators with balanced output usually have a 300-ohm output impedance. A one-to-one matching pad, as shown in Fig. 10-8 (B), may be required. This minimizes standing waves, which arise from the fact that the input impedance of the receiver is not constant for each channel. Receiver impedance changes are seen as much smaller changes by the generator looking into the pad.

Use of a pad results in a smaller signal across the receiver input than is put out by the generator. In the pad shown in Fig. 10-8 (B) approximately 50 percent of the generator signal appears across the receiver antenna terminals.

The percentage of signal fed to the receiver can be increased, but at a slight loss in the effectiveness of the matching pad. The values of pad resistors required to give greater generator signal across the receiver are shown below. Column 1 shows value of resistors required to replace each of the 47-ohm resistors, while Column 2 gives the value required to replace each of the 220-ohm resistors in Fig. 10-8 (B).

Column 1 (ohms)	*Column 2 (ohms)*	*Generator Signal Across Receiver Terminals*
30	360	67%
22	510	75%

2. PROCESSES IN TUNER ALIGNMENT. Tuner alignment involves two separate processes. These are:

a. Adjustment of the r-f circuits, including the grid and plate of the r-f amplifier, and the grid of the mixer.

b. Adjustment of the local oscillator frequency.

3. R-F ALIGNMENT. The method used almost exclusively for aligning the r-f circuits involves the use of a sweep generator, marker generator, and scope.

The sweep generator, set for high output, is coupled through an appropriate matching pad into the antenna terminals of the receiver. The direct probe of the oscilloscope, through a 10 K isolating resistor, is connected to the grid of the mixer. The local oscillator must not be disabled but must be operating, so that the mixer will be properly biased by oscillator injection voltage. The marker generator is loosely coupled to the mixer or the antenna circuit.

The sweep generator is then set to the midfrequency of the channel whose response is to be observed. The marker generator is calibrated for the sound and picture carrier frequencies for this channel. The generator sweep should be set for at least

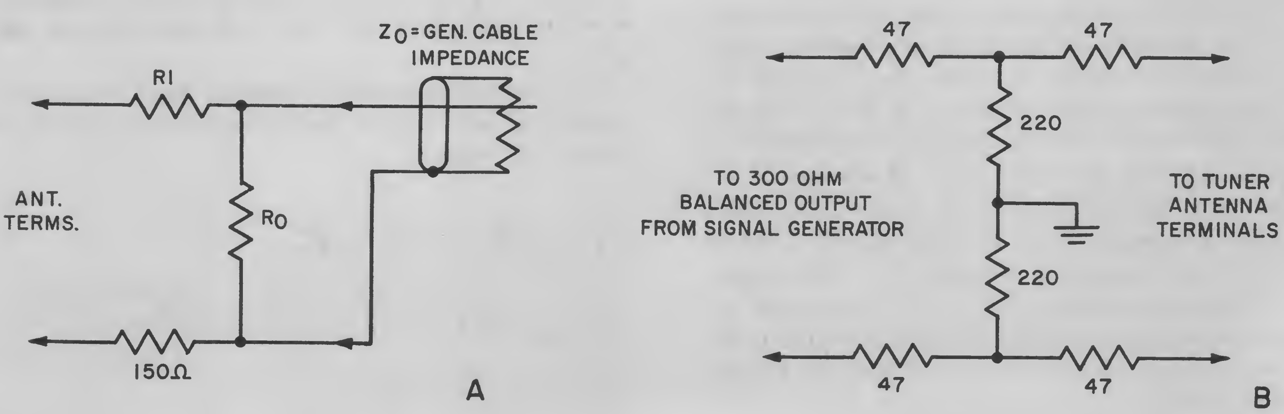


Fig. 10-8. Antenna matching pads. Courtesy Hallicrafters.

a 12 mc to 15 mc width. The receiver selector is set for the proper channel.

The technician then compares the observed response with that specified by the manufacturer and makes the necessary adjustments to shape it properly, both in amplitude and frequency.

There are a few general principles to guide the technician in this process. These are:

a. Gain. The gain of the curve is frequently controlled by the adjustment in the grid of the first r-f amplifier.

b. Frequency. This is frequently associated with the tuned circuit in the plate of the r-f amplifier.

c. Tilt. This is frequently associated with the tuned circuit in the grid of the mixer.

d. Bandwidth. This is usually a compromise between gain and frequency. However, there may be a special bandwidth adjustment in the front end.

In continuous-type tuners, there are also low- and high-frequency adjustments for uniform r-f response over the entire range of front end frequencies.

The manufacturer specifies the channel on which the adjustments are to be made. After these are completed, the technician observes the response curve on other channels. If there is a noticeable variation from the accepted response on the different channels, a satisfactory compromise may have to be made.

4. Oscillator Alignment

a. General. A variety of methods is employed in setting the oscillator on frequency. Several will be described.

In connection with this process the technician must recall that, in the wafer-type series-connected channel inductances, adjusting a higher channel frequency will also affect the oscillator frequencies of a lower channel.

In addition to the individual channel oscillator adjustments, most front ends contain a common oscillator adjustment which affects all channels. In a complete oscillator realignment this should be set first. Oscillator adjustments should be made with a nonmetallic screwdriver. In all oscillator adjustments the fine-tuning control should be set in the middle of its range and kept there.

b. On-Air Touch-Up. A local oscillator that has drifted slightly on a particular channel can be brought back to frequency by using the signal transmitted by the station. Adjustment is made for best picture and sound. If the channel is not on the air, instruments must be used.

c. Heterodyne Meter Method of Alignment. In this process the signal from the local oscillator is coupled to the heterodyne meter. The oscillator signal may be taken from the grid of the mixer or from the oscillator tube. In this latter case sufficient coupling may be secured by several turns of insulated wire around the oscillator. The free end of the wire is brought to the input of the heterodyne meter. The heterodyne meter is set to the local oscillator frequency for the desired channel, and the oscillator is then tuned for zero beat.

d. Heterodyne Method of Alignment. In this method a connection is brought from the mixer grid test point to the top of the volume control. A crystal-calibrated marker generator is coupled to the antenna and it is set on the exact frequency of the local oscillator of the receiver for the particular channel. One of the sound i-f tubes is removed or the f-m detector is disabled. The local oscillator is then aligned for zero beat. Here, the audio amplifier of the receiver acts as the aural indicator.

e. Response Curve Method. In this procedure it is necessary that the video i-f's and r-f amplifier and mixer be properly aligned first. A sweep generator is coupled through the proper matching network to the antenna terminals of the TV receiver. This generator is set up to sweep the channel on which it is desired to align the oscillator. The r-f picture carrier signal from a crystal-calibrated marker generator is fed to the front end. The response curve is observed in the output of the video detector. The local oscillator frequency is adjusted until the marker appears halfway down on the skirt of the over-all r-f i-f curve. This skirt may be on the right or the left side of the curve, depending on the hookup of the scope and the sweep generator. The position of the sound i-f carrier should then be checked and compared with the manufacturer's specifications.

When the marker has been set halfway down on the skirt, the oscillator is properly aligned. The same procedure applies to setting the oscillator frequency on each of the channels.

D. Sound I-F Alignment

1. General. Alignment of the sound i-f's involves two processes. These are:

a. Tuning of the f-m i-f amplifiers and the 4.5-mc sound take-off trap. (This method is for the intercarrier type of receiver.)

b. Tuning of the f-m detector.

2. Sound I-F Amplifier Alignment. The method of alignment is similar in all receivers. The 4.5-mc signal may come from various signal sources, however. Thus, the 4.5-mc sound i-f signal of the receiver itself may be used; or a crystal-calibrated 4.5-mc signal from a signal generator; or an f-m signal, sweeping about 100 kc on either side of 4.5 mc.

a. Transmitted TV Signal as Source. Use of the transmitted TV signal is a popular method of obtaining the 4.5-mc signal for sound i-f alignment. This method presupposes that the front end and

video i-f sections of a receiver have been properly aligned first. An operating channel is tuned in and the VTVM on the d-c scale is used as the indicator. It may be necessary to attenuate the signal at the antenna with a pad or to disconnect the antenna from the receiver if the signal is too strong. The 4.5-mc sound take-off trap and the i-f amplifiers, including the primary of the f-m detector, are tuned for maximum indication on the VTVM. The point at which the VTVM is placed depends on the type of f-m detector used.

If the f-m detector is a ratio detector, the VTVM is placed across the detector-biasing time constant. Thus, in Fig. 7-1 VTVM is placed from J400 to ground, on the negative scale.

If the f-m detector is a Foster-Seeley discriminator, the VTVM is placed across the half-load. In Fig. 7-2 this would be at the junction of the two resistors across the cathodes of V8 (the junction of R38 and R39). Signal level must be below the level required for limiting. *Note*: Frequently, the VTVM is first placed at the grid leak of the limiter (junction of R32 and C29 in Fig. 7-2). All preceding i-f adjustments, including the tuned circuit in the grid of the limiter, are then made. When this is completed, the meter is moved to the half-load, as previously identified, and the adjustment of the primary of the discriminator transformer is made.

A method for aligning the i-f's in a receiver using a 6BN6 gated-beam detector will be described separately.

b. Crystal-Calibrated C-W Signal Generator as Signal Source. The c-w signal generator, set at 4.5 mc, simply replaces the channel sound signal. Signal injection, through a 0.005-mf capacitor, is either into the output of the video detector or the grid of the video amplifier. Whichever gives greater isolation to the sound take-off trap is chosen as the point of injection. The VTVM is used as the indicator, and adjustment of the tuned circuits follows the same procedure as that previously described, using the transmitted TV air signal as the source. The output of the signal generator is kept low and is reduced as the adjustment of each tuned circuit is completed.

If the sound i-f circuits are completely out of adjustment and it is not possible to get a signal through from the video detector to the f-m detector, the proper procedure is to inject the signal, set for maximum output, into the grid of the stage closest to the f-m detector. The plate circuit of that stage is peaked for maximum. The signal generator is then moved back to the preceding grid and the intermediary circuits peaked. This process continues until the generator signal is finally injected into the output of the video detector.

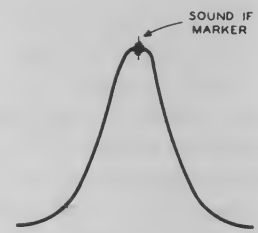


Fig. 10-9. Sound i-f response curve. Courtesy RCA.

c. Sweep Generator as Signal Source. The sweep generator is adjusted to sweep about 100kc on either side of 4.5 mc. It is coupled into the same point as the crystal-calibrated signal generator, as just described. A 4.5-mc marker is also injected into the circuit at this point. The direct probe of the scope is placed at the grid leak of the limiter, or into the half-load of the discriminator in the case of a receiver using a Foster-Seeley discriminator. If the receiver uses a ratio detector, a demodulation probe is used in the input to the scope and is connected to the plate of the driver (last i-f amplifier before the f-m detector). The 4.5-mc f-m i-f transformers (except the ratio detector transformer) are peaked for maximum indication at the 4.5-mc marker point. When this process is completed, the i-f response curve will be similar to that in Fig. 10-9.

3. F-M DETECTOR ALIGNMENT. Adjustment of the f-m detector is critical. An alignment tool with an insulated, nonmetallic blade should be used.

A similar process is followed, whether a ratio detector or discriminator is used.

a. Transmitted TV Signal as Source. Refer to previous discussion of sound i-f alignment using transmitted TV signal. The primary of the f-m detector transformer was adjusted at the time the i-f amplifiers were aligned. The secondary must now be tuned to frequency. The VTVM is zero-centered and placed across the full load, in the case of the discriminator (junction of R39 and R41 in Fig. 7-2). In the case of the ratio detector the hot lead of the VTVM is placed at the bottom of the tertiary winding of the detector transformer (pin No. 5 of Z401 in Fig. 7-1). The ground lead is placed at the junction of two equal resistors wired across the capacitor in the biasing *RC* network of the ratio detector. If these resistors are not part of the circuit, they must be temporarily installed during alignment of the f-m detector and removed at the completion. Usually, matched 100K resistors are used. The secondary is then tuned for zero output at 4.5 mc. It is easy to tell the proper point because minor readjustments of the secondary slug will cause the indicator to deflect on either side of zero center on the meter.

b. Crystal-Calibrated 4.5-Mc C-W Signal Generator as Signal Source. Signal injection is the same as in i-f alignment. The VTVM is placed across the same test points as described under transmitted TV signal alignment of f-m detector secondary. Adjustment of the secondary is the same as was described under transmitted TV signal alignment of the f-m detector secondary.

c. Sweep Frequency Generator as Signal Source. Sweep generator frequency, sweep controls, and 4.5-mc marker injection are same as was described in this section under sound i-f alignment, using a sweep frequency generator. The scope direct probe is placed at the same test points as was the VTVM in f-m detector alignment. The secondary of the detector is then adjusted for crossover of the S-curve at 4.5 mc. The primary is readjusted for proper symmetry of the curve. See Fig. 10-10 for proper f-m detector response.

It may be difficult to adjust the secondary properly because the marker disappears in the region of crossover. It is possible to overcome this by using an a-m 4.5-mc marker instead of c-w marker during this process. Before adjustment of the secondary is completed, the a-m will appear as shown in *A* and *B* in Fig. 10-10. (Sweep generator, with retrace blanking to create a zero base line, is used here.) When the secondary is proprly tuned, the a-m will be reduced to minimum or will disappear as shown in *C* of Fig. 10-10.

4. ALIGNMENT OF THE GATED-BEAM DETECTOR. Manufacturers using the 6BN6 as an f-m detector usually recommend an air signal alignment procedure. However, it is possible to use instruments, so both methods will be described.

a. Transmitted TV Signal. The receiver is tuned to a TV station which is on the air. A step attenuator (such as that shown in Fig. 6-18) is connected between the antenna and receiver input terminals. The buzz control (see Fig. 7-3) is set in the middle of its range. The sound take-off and i-f adjustments (L19 and L22, Fig. 7-3) are set for maximum program sound. These are rechecked with signal at its lowest level (maximum attenuation).

A strong signal is then applied to the receiver input and the quadrature coil (L23, Fig. 7-3) adjusted for maximum sound.

A very weak signal is then applied. It should be possible to hear hiss or noise. The buzz control is then set for minimum noise or buzz.

b. Signal Generator and Oscilloscope or Output Meter. The output of an a-m generator, accurately set at 4.5 mc, is fed to the sound take-off circuit. The feed point must be isolated from the take-off circuit so that the impedance of the generator will not load it. A scope or an output meter is then placed at the top of the volume control. The quadrature coil is detuned. The other 4.5-mc coils are tuned for maximum indication with minimum generator output. The quadrature coil is tuned for minimum in-

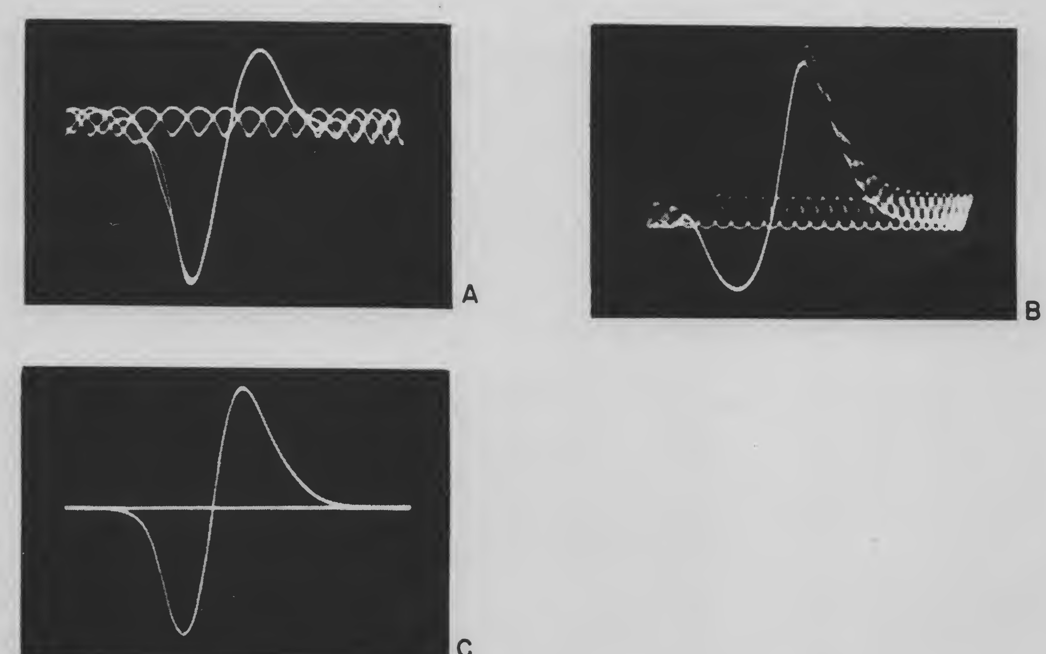


Fig. 10-10. A-M marking of discriminator alignment curve.

dication with high generator output. This null point may be identified by the fact that there is a definite increase in output on either side of the null setting.

The buzz control is then set for minimum a-m output. The proper setting is the point on either side of which there is an increase in a-m output.

CHAPTER 11. ANTENNAS AND TRANSMISSION LINES

A. Introduction

1. FUNCTION. The antenna is used to intercept TV signals which are radiated by a transmitter. This signal is fed to a transmission line which conveys the signals to the receiver. The receiver then converts the signals to video and sound information.

2. COMPONENTS. The antenna system consists of:

a. The receiving elements and their support.

b. The transmission line with its stand-offs and lightning arrestor.

c. Any impedance-matching units or rotor assemblies which might be incorporated into the system.

3. CHARACTERISTICS. Each antenna has specific performance characteristics. These determine what type of antenna may best be used for a particular installation. These characteristics are governed by physical configurations and are interdependent. They include:

a. Frequency Range: the useful range of frequencies which the antenna is capable of handling.

b. Gain: the output signal strength as compared to a standard dipole. Figures for gain in decibels (over a range of frequencies) are placed in graphic form to simplify antenna evaluation. See Fig. 11-1 (B).

c. Horizontal Directivity: response curves illustrate the relative field strength of a particular antenna at a particular frequency in all horizontal directions. Refer to Fig. 11-1 (C). This horizontal pattern indicates that at Channel 14 the stacked bow-tie antenna has a major forward lobe of much greater response than the minor rear lobe. This is what is meant by good front-to-back ratio. At Channel 83 this antenna has two more major lobes. These additional lobes permit a single orientation of the antenna for Channels 14 and 83, even though their directions are 60 degrees apart.

The beamwidth of the major lobe (s), usually specified at the widest points or at the half-power points, refers to the angle between two equal reference points on the major lobe (s). The beamwidth determines the directive selectivity characteristic of the antenna. Thus, wide beamwidth permits reception from different directions. Narrow beamwidth, on the other hand, reduces possible interference or unwanted signals which do not originate in the same direction as the desired TV signal. Figure 11-1 (C) shows a single lobe with wide beamwidth for Channel 14 and three major lobes with narrow beamwidth for Channel 83, for the stacked bow-tie.

Occasionally, manufacturers refer to *vertical directivity*. This means the relative field strength in the vertical plane.

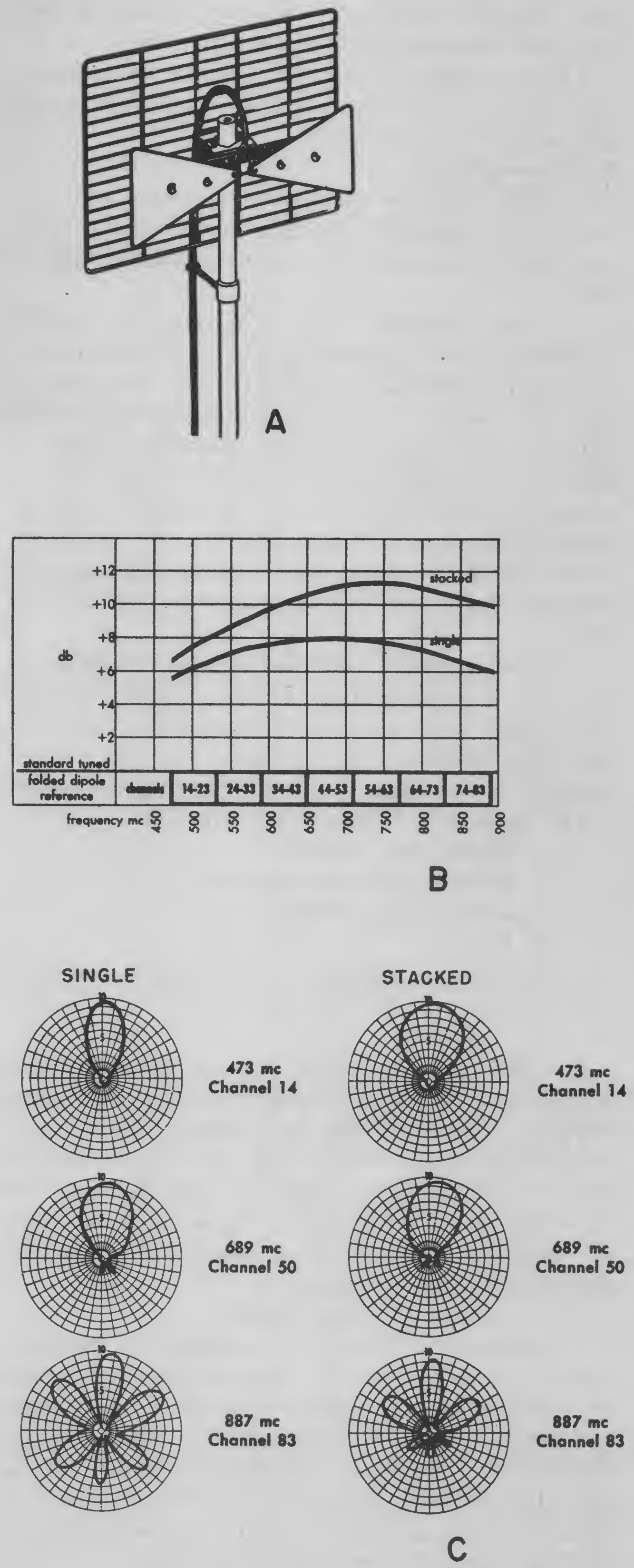


Fig. 11-1. Bow-tie antenna. *Courtesy Amphenol.*

d. Impedance: the value which determines the most efficient load into which the antenna may operate. Matched impedances produce minimum losses and minimum standing waves on the line.

Antenna characteristics are affected by moisture, proximity to mineral deposits or other objects, and transmission-line mismatch.

B. Antenna Types

1. VHF. The size of antenna elements varies inversely with frequency. At vhf, element size is fairly large and antenna design is more restricted than at uhf.

Antennas designed for the vhf range are usually broadband, covering both the high- and low-frequency channels. They are modifications of the basic dipole. The nature of the modification determines the antenna characteristics. Present practice accepts installation of these antennas either as they are or stacked. Vertical or horizontal stacking is used to obtain additional gain and improve the directivity of the system. In fringe areas narrowband high-gain antennas (such as the Yagi and stacked arrays) are used.

Window and indoor antennas are used in good signal areas or where outdoor antennas cannot be used. Restrictions as to size and location limit their performance. However, the proximity to the receiver permits the advantage of adjustment on each channel.

The common vhf antenna types include:

a. Dipole and reflector.
b. Folded dipole and reflector.
c. Conical and reflector.
d. Circle.
e. V-Beam, also used for uhf or as a combination vhf-uhf antenna.
f. Trombone.

2. UHF. In the uhf band many types of antennas are practical, due to the smaller physical dimensions required. Antennas made for a specific channel or a small band of channels provide greater gain and are more frequently encountered in uhf. Reflectors of more radical design are used to provide greater gain and greater attenuation of unwanted reflections and signals from sides and rear.

The common uhf types include:

a. Bow-tie. This antenna without a reflector exhibits the properties of a simple dipole and should be used only in strong signal areas where interference and ghosts are not a factor. With a reflector (Fig. 11-1), it is a high-gain broadband antenna with a good front-to-back ratio over most of the band. A stacked bow-tie gives an excellent front-to-back ratio, with increased gain over the entire band.

b. Yagi (Fig. 11-2). This is a narrowband antenna which exhibits high gain characteristics over the range of channels for which it is cut. In its range it is directional and, depending on design, covers approximately 3 to 10 adjacent channels near the low-frequency end of the uhf band to approximately 8 to 15 adjacent channels at the high-frequency end.

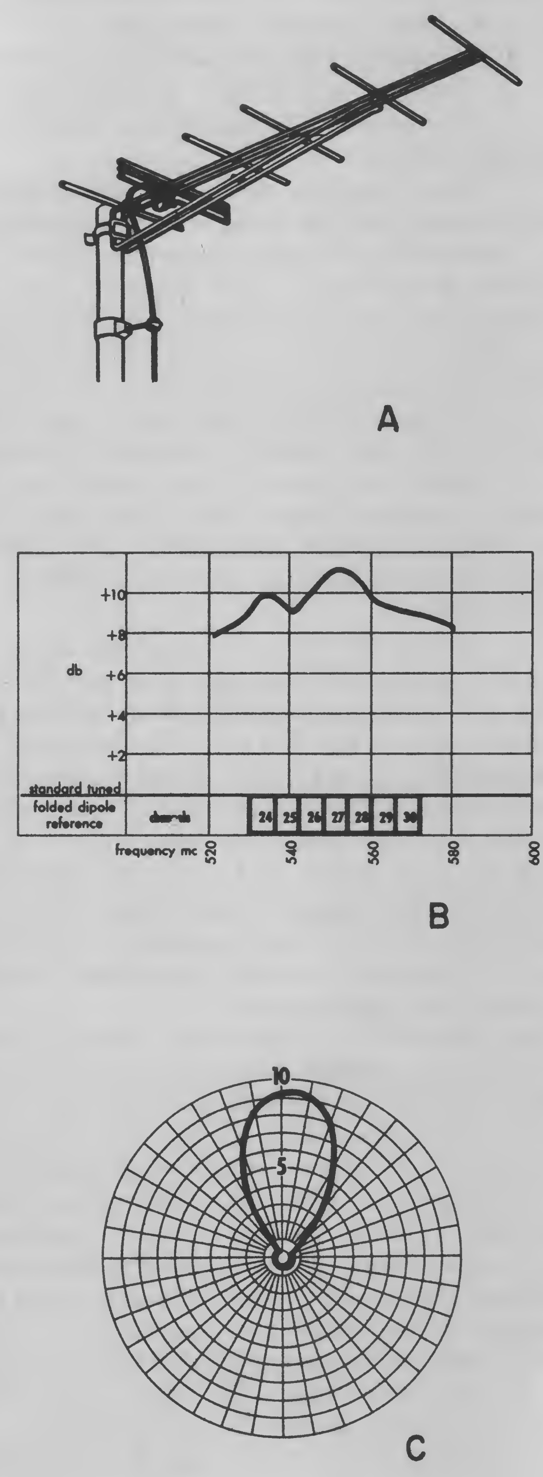


Fig. 11-2. Yagi antenna. Courtesy Amphenol.

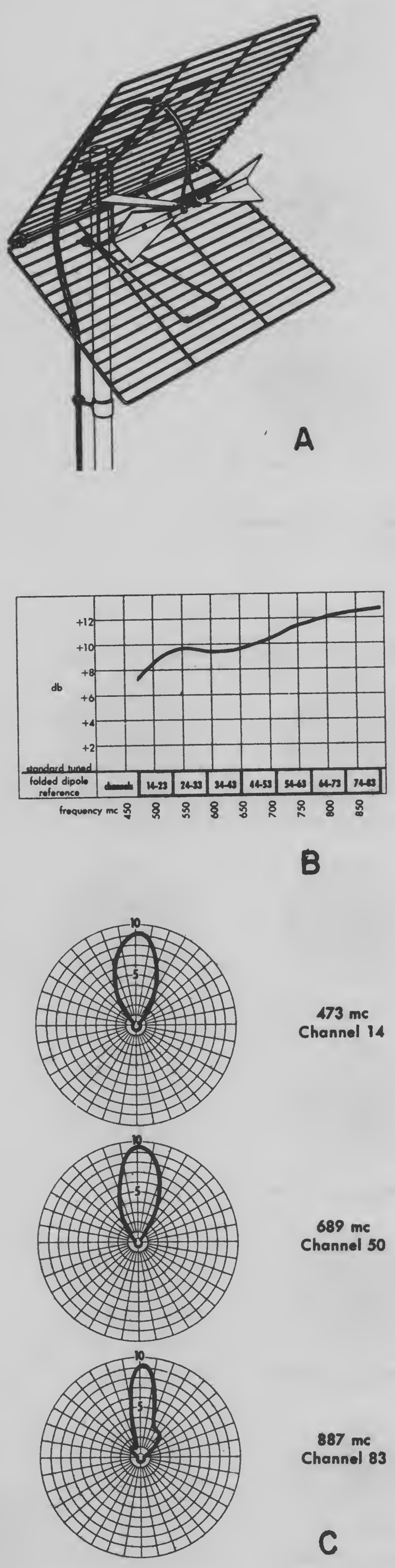


Fig. 11-3. Corner reflector antenna: (A) corner reflector; (B) gain chart; (C) horizontal directivity pattern. *Courtesy Amphenol.*

This antenna is well suited for single-channel reception. Its narrow beamwidth, in conjunction with a single major forward lobe, reduces unwanted signals. Thus, reflections and interference are minimized and high gain is maintained.

c. Corner Reflector (Fig. 11-3). This antenna is a modified version of the bow-tie antenna. Like the bow-tie, it is a broadband high-gain antenna. The gain is a little greater than the bow-tie over the entire band, and the radiation pattern indicates narrower beamwidth, with a single major lobe and excellent front-to-back ratio. The vertical directivity is improved, which means that unwanted signals above and below the direction of signal reception are attenuated.

d. The Rhombic (Fig. 11-4). This is a broadband high-gain antenna with very narow beamwidth in the major forward lobe. Some minor lobes do exist, but the front-to-back ratio is good. A terminating resistor is used on the forward end of the array. This antenna requires more than normal horizontal space, but it greatly attenuates ground reflections.

e. Stacked "V" (Fig. 11-5). This is a versatile antenna which can be used as a uhf antenna or as a combination uhf-vhf antenna. Its use for vhf reception alone is limited, due to its low gain in the region of Channels 2 to 6. The open end of the "V" is faced toward the transmitter and the angle between the arms of the "V" is adjusted for the desired band. The beamwidth, directivity, number of major lobes, and front-to-back ratio vary with the selected angle. The V-beam and trombone antennas are modified versions of this antenna.

f. Colinear Array. Another type of uhf antenna is the colinear array (Fig. 11-6). This may consist of either straight or folded dipoles connected in phase vertically. For stacking purposes, two arrays are set up horizontally.

Antenna selection depends on the problems involved. Antenna characteristics are analyzed as to gain, directivity, beamwidth, number of and width of major lobes, front-to-back ratio, and physical size. Stacking of antennas usually increases the desirable features and may be used to help overcome difficult reception problems.

C. Transmission Lines

For maximum efficiency the power in the antenna must be transferred to the receiver with a minimum amount of loss. This function is served by the transmission line. Important considerations in the selection of the proper transmission line include impedance, losses, durability, and ease of handling. Line losses are not constant but are dependent on moisture, dirt, and mineral deposits, and on proximity to conductors. Table VII indicates the approximate line

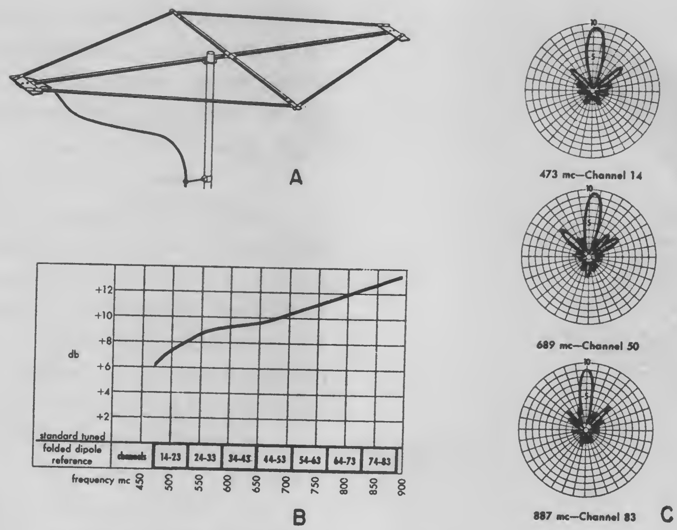
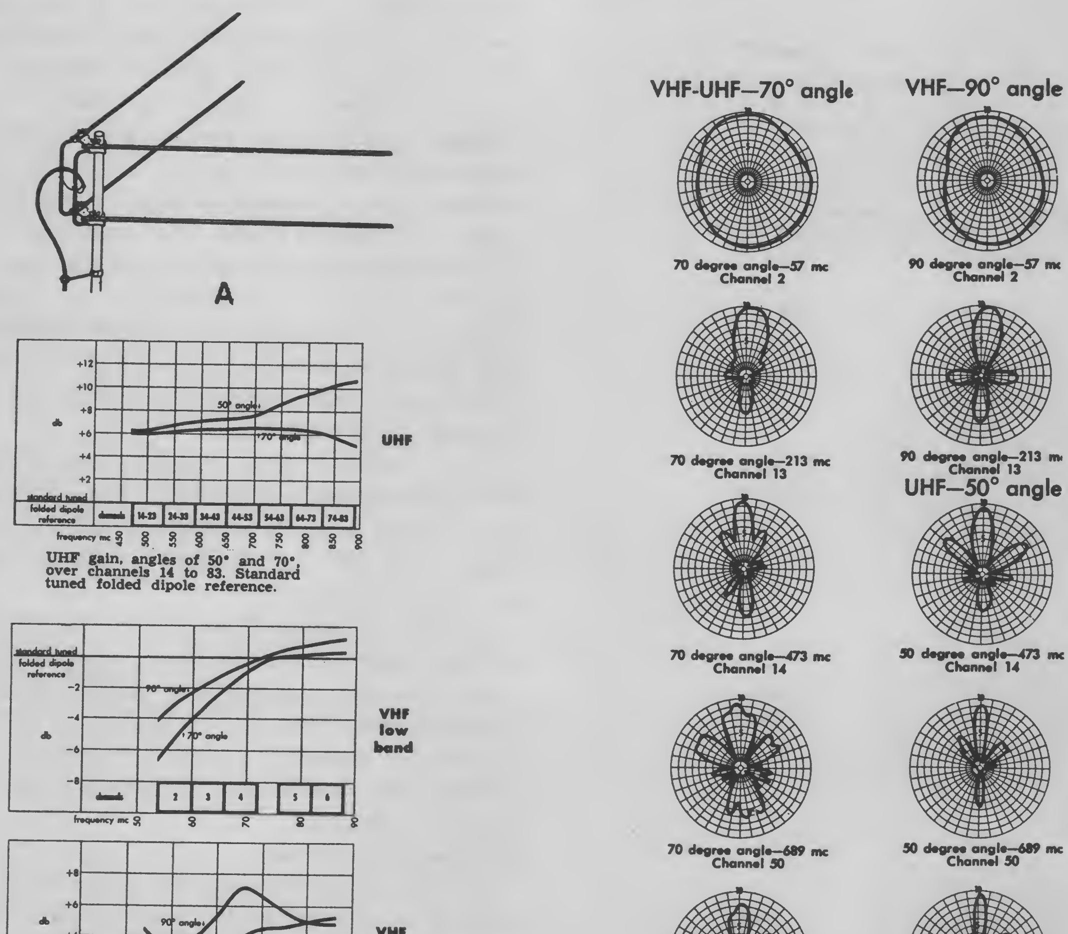


Fig. 11-4. Rhombic antenna: (A) rhombic; (B) gain chart; (C) horizontal directivity pattern. *Courtesy Amphenol.*



UHF gain, angles of 50° and 70°, over channels 14 to 83. Standard tuned folded dipole reference.

VHF gain, angles of 70° and 90°, over channels 2 to 13. Standard tuned folded dipole reference.

Fig. 11-5. Stacked-V antenna: (A) stacked "V"; (B) gain chart; (C) horizontal directivity pattern. *Courtesy Amphenol.*

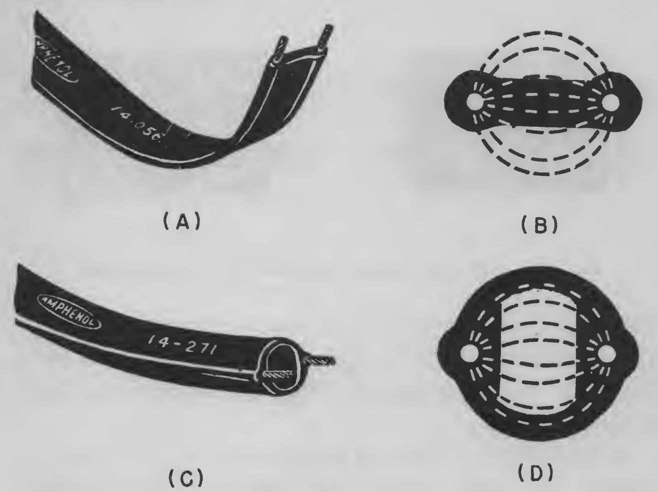
TABLE VII

Type of Line	Loss at 500 mc (in db)	
	Dry	Wet
Flat	3.5	20
Tubular	3	7
Coaxial (RG 59/U)	9.5	9.5
(RG 11/U)	5	5
Slotted (punched)	3	10
Sheathed (flat)	3	6
Open-wire	2	4
Oval	2	4

losses (in db per 100 feet) of various types of transmission line.

The 300-ohm transmission line is now considered the standard throughout the TV industry. Two popular types are illustrated in Fig. 11-7 (A) and (B). In strong signal areas flat-type line is used for economy purposes. Tubular line, on the other hand, has superior performance characteristics as frequency and moisture content rise. Figure 11-7 (C) and (D) illustrates the principle on which this superiority is based. With tubular line the major energy field is within the confines of the line, while flat line permits a good portion of this energy field to exist outside the line where it can be adversely affected by moisture, dirt, and mineral deposits. This causes additional losses and impedance changes.

The transmission-line types include the slotted 300-ohm. The principle of design is based on flat line with some of the spacing insulation removed. The advantage of air insulation is slightly lower losses while maintaining ease of handling. Slotted line, as



signal loss

	100 MC Dry	100 MC Wet	500 MC Dry	500 MC Wet	1000 MC Dry	1000 MC Wet
1. Flat 300 ohm	1.2	7.3	3.2	20.0	5.0	30.0
2. Tubular 300 ohm	1.2	2.5	3.0	6.8	4.6	10.0

(E)

Fig. 11-7. Transmission line, 300 ohms: (A) flat line; (B) tubular line; (C) energy field of flat line; (D) energy field of tubular line; (E) Db attenuation per 100 ft. *Courtesy Amphenol.*

well as flat line, comes with a sheath of polyethylene. This sheathed line has lower line loss characteristics than ordinary flat or slotted line and is used where weather conditions affect line characteristics.

Open-wire line consists of two conductors properly spaced by polystyrene spacers placed at equal intervals on the line. This line is commercially available in 375-ohm and 450-ohm impedance. It is not widely used in strong signal areas, due to the possible additional impedance mismatch and the difficulty of handling.

Coaxial cable consisting of an inner conductor equally spaced from the outer conductor, which is a surrounding sheath, is no longer popular in the TV industry. It is used, however, where interference may be picked up by the transmission line. It is available in impedances of 50, 72, and 92 ohms, with the 72-ohm the more popular. It requires proper matching to the 300-ohm input of a TV receiver. Thus, where noise pick-up by the transmission line becomes a problem, 72-ohm coaxial lead with proper matching or a 300-ohm shielded lead must be used.

D. Antenna Coupling Networks

1. VHF-UHF Couplers (Crossover Networks)

a. Networks such as those shown in Figs. 11-8 and 11-9 provide a means of bringing the output from separate vhf and uhf antennas into a receiver. The networks consist of tuned circuits, which effect isolation between antennas.

Two antennas, one covering the vhf, the other the uhf band, may be coupled to one transmission line,

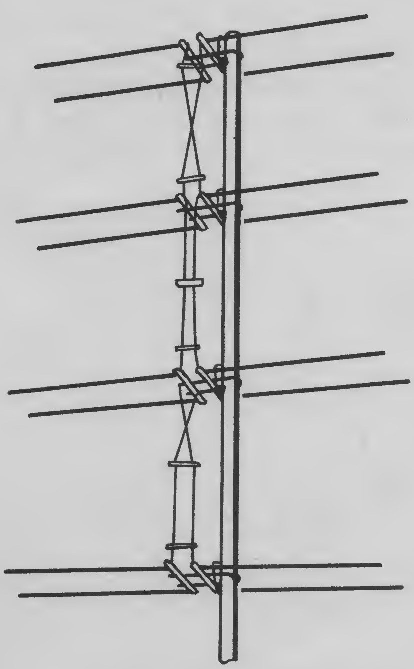


Fig. 11-6. Colinear antenna. *Courtesy Vee-D-X.*

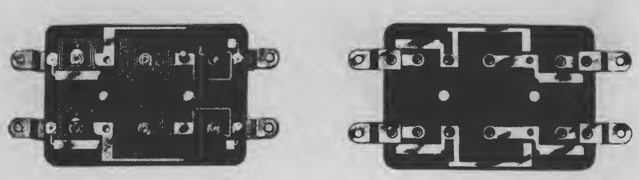


Fig. 11-8. UHF-vhf antenna couplers. Courtesy Vee-D-X.

either at a common antenna mast or from widely separated antennas. The coupler may be placed at any point on the transmission line, up to the terminals of the receiver.

If the coupler is placed at the receiver, it is used to permit the two transmission lines to be properly matched to the single receiver input. The network consists of tuned circuits which prevent interaction between antennas. For proper hookup, see Fig. 11-10 (B) and (C).

b. A single transmission line may be coupled to a receiver which has separate vhf and uhf input terminals. One antenna may function as a vhf-uhf antenna with a single lead which must couple to individual vhf and uhf receiver terminals. The coupling network receives the combined signal at one set of terminals. It is then distributed from two additional terminals to the proper input circuits. The same tuned-circuit principle is used for effecting a reduced interaction between input circuits. For proper hookup, see Fig. 11-10 (A).

c. A combination of (a) and (b), as in Fig. 11-10 (D), may be used where two antennas feed into a single transmission line which must in turn feed two individual input circuits.

2. MULTISET COUPLERS. One antenna system may be coupled to two or more receivers (Fig. 11-11). A simple matching network is used (except for amplifying systems). A matched impedance is maintained. Attenuation arising from the network is kept to a minimum, except where it is required to reduce receiver interaction. Generally, increased insertion loss reduces interaction. In other words, the greater the value of R_1, (Fig. 11-11), the smaller is the signal reaching the receivers and the greater is the isolation between them.

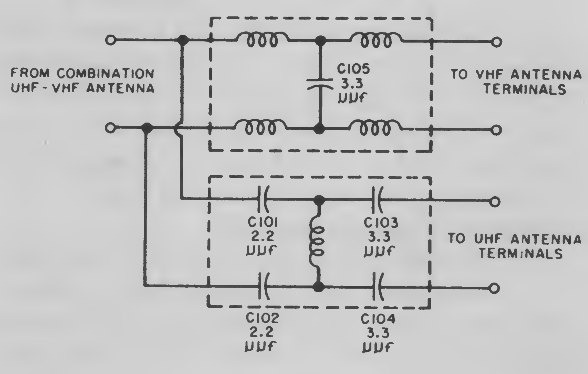
Wherever matching networks are used, some insertion loss must be present. Under normal conditions, insertion loss is fairly low in systems employing vhf-uhf couplers and higher in multiset couplers without amplifiers.

In all cases transmission lines, antennas, and receivers must be properly matched. If improperly matched, standing waves on the transmission line become excessive. This causes cancellation of signal power, with attendant signal attenuation. A close ghost may also be traced to line mismatch. Simple matching transformers may be constructed, using resistors for multichannel reception. This is done in strong signal areas only. More complicated matching networks for single-channel reception may be constructed, using matching stubs or quarter-wavelength matching sections. Matching transformers are available commercially.

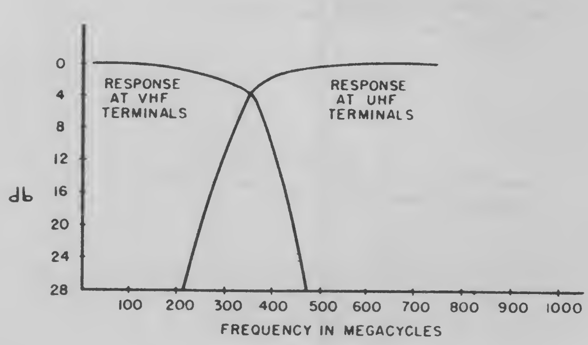
3. RESISTANCE IMPEDANCE-MATCHING PADS. Resistive networks may be used for matching two line impedances or for padding (signal attenuation). The resistive impedance seen by the line to be matched must always be equal to the line impedance. Thus, a 72-ohm line must be connected across an equivalent 72-ohm network.

Resistive impedance-matching networks introduce large signal attenuation and can be used only in strong signal areas. Carbon resistors are employed in constructing these pads.

Figure 11-12 (A) illustrates both balanced and unbalanced resistive matching pads. Values of R_1 and R_2 required to match output impedance Z_o to input



A



B

Fig. 11-9. (A) Schematic of DuMont crossover network. (B) Response curves. Courtesy DuMont Service News.

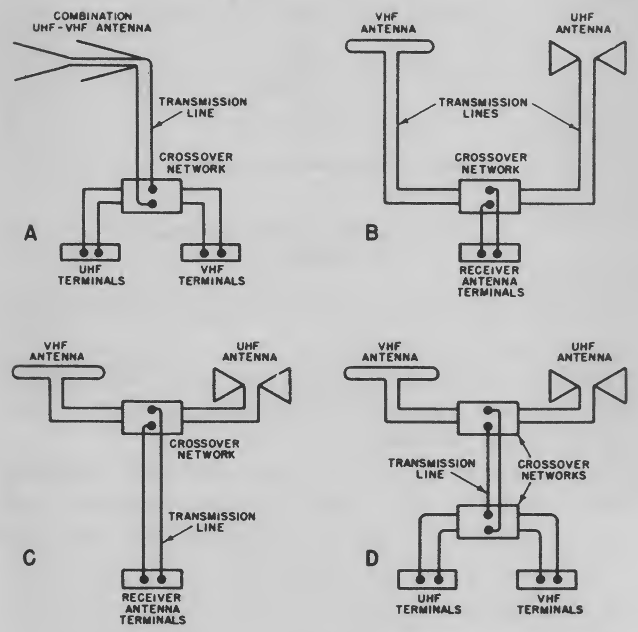


Fig. 11-10. Crossover network hookups. (A) Combination uhf/vhf antenna used with a dual input receiver. (B) Separate uhf/vhf antennas used with a single input receiver. (C) Same as (B) except network is mounted on the antenna mast. (D) Separate uhf/vhf antennas to a dual input receiver using a single transmission line. *Courtesy DuMont News Service.*

impedance. Z_{in} may be gotten by substitution in the formulas:

$$(1)\quad R_1 \times R_2 = Z_{in} \times Z_o$$

$$(2)\quad R_2 = \frac{(Z_o - Z_{in})}{Z_{in}} \times R_1$$

Table VIII, reprinted by courtesy of the RCA Service Co., gives practical values of R_1, R_2, and $R_2/2$ obtained from formulas (1) and (2). All values are in ohms.

TABLE VIII

Z_{in}	Z_o	R_1	R_2	$R_2/2$
50	300	56	270	150
75	300	82	240	120
150	300	220	220	100

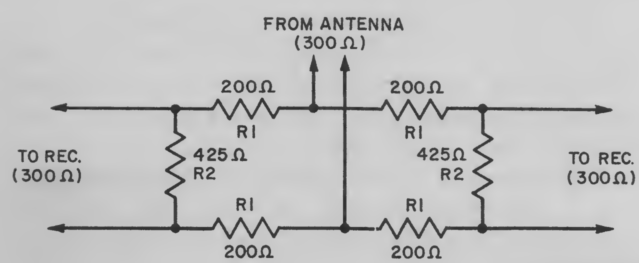


Fig. 11-11. Resistance network for operating two receivers from one antenna.

4. Resistive Attenuating Pads. Attenuating pads may be required in an area of excessive signal strength to prevent overload or to provide additional isolation between nearby receivers. The amount of attenuation needed can be determined experimentally by use of a step attenuator such as that illustrated in Fig. 11-12 (B). The technician then builds an equivalent resistive pad.

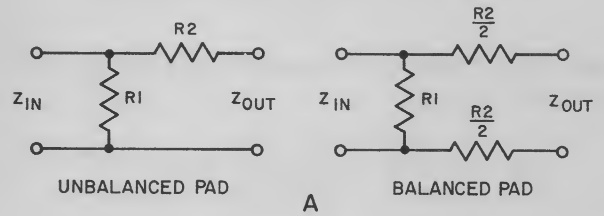


Fig. 11-12A. Resistive matching pads. Note: Interchange input and output terminals for high to low impedance-matching. *Courtesy RCA Service Co.*

B

Fig. 11-12B. Step Attenuator. *Courtesy Zenith*

a. Balanced Pad. Figure 11-13 shows a balanced pad for use between a 300-ohm line and a receiver with 300 ohms input impedance. Value of R_1 and R_2 may be determined from the formulas:

$$(3)\quad R_1 = 150 \times \frac{A-1}{A+1}\text{ohms}$$

$$(4)\quad R_2 = 600 \times \frac{A}{(A+1)(A-1)}\text{ohms}$$

where A is the number of times the input voltage must be decreased. Table IX lists practical values of R_1 and R_2 derived from formulas (3) and (4) for specific values of attenuation. All values are in ohms.

TABLE IX

R_1	R_2	*Ratio of Input Voltage at Output* ($1/_A$)	*Loss* (*db*)
120	68	1:10	20
82	220	1:3	10
47	390	1:2	6
24	910	5:7	3

b. Unbalanced Pads. An unbalanced attenuating pad, for use between a 72-ohm line and a receiver with 72 ohms input impedance, is shown in

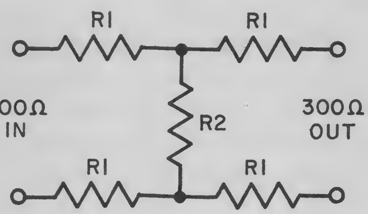


Fig. 11-13. Balanced 300-ohm attenuating pad.

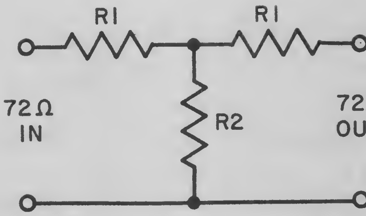


Fig. 11-14. Unbalanced 72-ohm attenuating pad.

Fig. 11-14. Values of R_1 and R_2 may be determined from the formulas:

$$(5)\quad R_1 = 72 \times \frac{A-1}{A+1}\ \text{ohms}$$

$$(6)\quad R_2 = 144 \times \frac{A}{(A+1)\,(A-1)}\ \text{ohms}$$

where A is the number of times the input voltage must be decreased.

Table X lists practical values of R_1 and R_2 derived from formulas (5) and (6).

TABLE X

R_1	R_2	*Ratio of Input Voltage at Output* ($^1/_A$)	*Loss (db)*
56	15	1:10	20
33	51	1:3	10
22	100	1:2	6
12	220	5:7	3

E. UHF Installation Practices

1. General. The good practices involved in vhf installations are followed in uhf. The more critical aspects of uhf, however, require additional precautions and techniques. Due to the shorter wavelengths of uhf, the wave propagation characteristics are modified in the following manner:

a. Less Refraction. This is bending, caused by different densities of the atmosphere through which the wave must travel. Transmitted uhf waves are line-of-sight and bend less than vhf waves with the curvature of the earth.

b. More Reflections. The smaller waves may be reflected by smaller objects and thus create a greater number of reflection possibilities.

c. Less Diffraction. When a transmitted wave passes a solid body, the wave tends to break up, with part of the wave bending around the solid body. With uhf this bending is reduced, with a resultant decrease in signal behind solid bodies.

d. More Points of Signal Cancellation. One signal may reach an antenna through two different paths. The phase of the two waves may add, cancel, or fall somewhere in between these two conditions. With shorter wavelengths, more points within a given area may exist where there are large cancellations or additions of signal power.

2. Considerations in Installing the UHF Antenna. The uhf installation requires particular attention to these problems.

a. Antenna and Transmission-Line Selection. The channel (s) to be received determines the basic type of line to be used. For single-channel reception a narrowband antenna, specifically designed for that channel, will give superior results. Where more than one channel is to be received on a single antenna, an antenna broadband enough to receive these channels must be selected. Moreover, the amount of signal and the extent of interference in a particular area are factors that must be considered in the selection of a proper antenna and transmission line.

Choosing an antenna is not always a simple matter of evaluating characteristics and obtaining a single conclusive result. This is because all the factors involved are not always known. It may be necessary to experiment with different antenna types. Experience will usually indicate the proper type for a particular area. However, due to unrecognized differences in areas, results may vary.

Transmission lines must be selected to give a minimum amount of attenuation in weak signal areas. The possibility of moisture and mineral deposits on the transmission line should be considered. Local man-made interference from machines, ignitions, and neon signs may require the use of shielded or coaxial line.

Standard equipment properly installed will withstand rigors of the weather. However, excessively high installations in windy areas require particular attention to insure durability.

b. Choice of Site. This is usually limited to availability, but may include erection of towers in some cases. Height is important, but structural strength, durability, serviceability, and appearance must also be considered. A field strength meter, if available, is used to probe the site for maximum signal strength.

c. Mounting Antenna and Routing Transmission Line. Mechanically, the installation must be capable of withstanding any extreme condition which may arise. The antenna must not sway excessively.

All safety precautions and building codes must be observed. Care must be taken to prevent damage to any property. The transmission line should be as short as possible, spaced at least 6 in. from any metallic objects or wire, and securely mounted at correct intervals. It is desirable that external connections at the antenna be protected by plastic paint or spray.

Special techniques must be employed with tubular transmission line, including proper stand-offs. If not properly handled, the wire may act like a hose to pour rain water and moisture condensation into the home. Therefore, the top end must be sealed. A polyethylene end seal (Fig. 11-15) may be used. Another method (A in Fig. 11-16) is to apply heat to the open end of the wire and crimp it to form a seal. Where the tubular line enters the home, a small drip loop must be formed which goes below the point of entry. At this point a small hole is made in the line to permit moisture to drain out before the line enters the home. See Fig. 11-16 (B). The tubular line should be connected directly to the receiver, but where this is not practicable, a splice may be made between flat and tubular line to permit entry of the line into the home without drilling, or for ease of handling or appearance. Excess line must be cut off and never coiled up. The tubular line must be sealed and the 300-ohm impedance maintained by proper physical alignment of the wire at the splice. The transmission line must be protected from sharp edges and from rubbing against ledges. An insulated covering, such as a small length of large spaghetti, and rigid mounting will properly protect against abrasive action at these points.

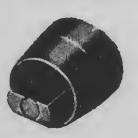


Fig. 11-15. End seal for tubular line. Courtesy Amphenol.

Impedance-matching is normally not a problem. This is because of the wide impedance variations which permit acceptable operation. However, loss of signal and/or ghosts may be due to line mismatch. In these cases line-matching should be tried. Refer to previous discussion on matching. In a rapid check for indications of mismatch, the transmission line (not coax) is tightly grasped (this may be any part of the line). The hand is then moved up and down the transmission line for a short distance. If no appreciable effect on picture quality is noticed, then the line is matched. A mismatched line would have standing waves which would be affected by the movement of the hand.

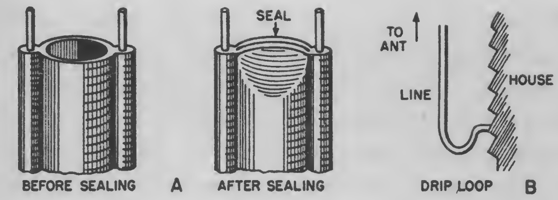


Fig. 11-16. Sealing a tubular line.

d. Orientation and Customer Instruction. Orientation of the antenna with respect to the transmitter and reflecting surfaces must be determined experimentally while the receiver or a field strength meter is in operation. If a receiver is used, orientation is facilitated by the use of a communication system, such as sound-powered phones. The technician who is outside positions the antenna. The technician in the house observes the effects on reception and selects the antenna position which gives optimum performance.

Orientation on a reflected wave may cause variable reception. This is due to changes in reflections caused by moisture, atmospheric conditions, and such unique factors as the raising and lowering of a gas storage tank. Therefore a direct signal should be used wherever possible.

The antenna is not necessarily pointed directly at the transmitter. The antenna may have a lobe off-center or the main center lobe may be positioned off-center to receive adequate transmitter signal while attenuating unwanted interference or ghosts. In strong signal areas antennas are oriented for minimum ghosts while maintaining sufficient signal input. In fringe areas maximum signal strength with minimum interference is desired. Thus, by critical horizontal orientation of the antenna, lobe (s) may be positioned to miss undesired signals while receiving the desired signal. Vertically, the antenna may be positioned to a point of in-phase reception. Hence, although height normally is desirable, it may be possible to obtain a stronger signal by either lowering or raising the antenna a few feet, as has already been explained.

After an installation is completed, the customer should be given operating instructions. It is part of the technician's job to be certain that the customer knows how to operate his receiver properly. Any special instructions connected with converter operation, switching, or tuning should be explained in detail. Furthermore, customers should be advised to leave unshielded transmission lines unpainted and to keep other wiring at least 6 in. away from the line.

CHAPTER 12. TELEVISION INTERFERENCE

Technicians are frequently called upon to deal with problems of television interference (TVI). The customer is irritated by an interference pattern on the screen and thinks there is something wrong with the receiver. On recognizing the problem, the technician may pass it off with, "Oh, that's TVI. There is nothing we can do about it."

It is often possible to do something about reducing or eliminating TVI. The solution of the problem depends on the nature of the interference.

A. Report of Washington Television Interference Committee

The following material is reprinted from the report of the Washington Television Interference Committee, prepared in cooperation with RETMA and the FCC, on the problems of TVI.

TVI Elimination—Common Goal for All! Manufacturers, Dealers, Technicians, Interfering Services, Viewers.

The average television receiver owner is not trained either to diagnose or to understand his personal interference situation. He requires honest and intelligent advice from his service technician. A competent service technician usually can determine whether the interference is due to harmonic radiation on the channel frequency or whether the interference is localized at the receiver.

Television Receiver Problems

Although television receivers are designed to receive stations operating in the television bands, they may, under certain conditions, respond to signals transmitted on frequencies far removed from the frequency to which the receiver is tuned. Receiver conditions which most frequently cause undesired response are: (1) insufficient intermediate frequency rejection; (2) insufficient image frequency rejection; (3) insufficient rejection to strong local signals not operating in the normal receiver passband.

The TV receiver manufacturers recognize that the most frequent causes of television interference are those just enumerated, and the new TV receivers of the leading manufacturers have circuit features adequate to reject strong radio signals operating on frequencies outside the television bands.

We are concerned with many TV receivers now in use that do not have built-in filters or other circuit features of adequate selectivity to reject strong low-frequency signals (3 mc to 30 mc).

Sources of TVI

There are many sources of TVI. Some of the more common include: (1) diathermy (2) radiation from local oscillators of TV and f-m broadcast receivers (3) strong signals from nearby radio stations, including f-m broadcast, amateur, police, taxi, and governmental and military services (4) ignition-type interference sources (5) cross-modulation conditions.

It should also be remembered that as certain receiver parts age, the TV receiver may become more susceptible to all types of interference. A faulty sound trap or its misadjustment, an intermittent, or other receiver defect might result in a pattern similiar to that produced by an outside source.

The Radio Amateur Is Not Always at Fault

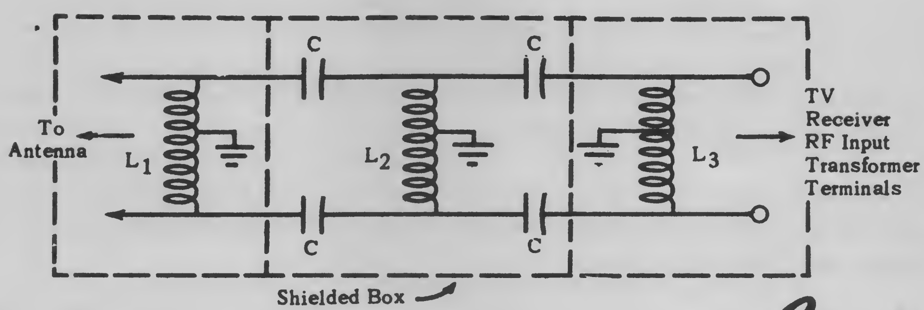
The radio amateur is actually involved in only a small portion of this over-all interference picture. It must be remembered that an amateur operating his station on authorized frequencies is at fault for TVI only when his equipment is radiating harmonics or spurious frequencies. Unfortunately, many set owners and some technicians are prone to blame the radio amateur for most TVI.

Where a radio amateur can demonstrate that his own commercial standard TV receiver, when in close proximity to his transmitter, is free and clear of interference while he is transmitting, it is reasonable to expect that other neighboring TV receivers, which may be affected by the fundamental signal from the amateur station, can be made just as free and clear of interference from that amateur station. The Washington District Office of the FCC has noted that approximately 90 percent of amateur interference cases referred to them have been cleared by installation of a high-pass filter in the receiver.

What Is the High-Pass Filter?

The high-pass filter is a device which allows signals of frequencies above the cut-off frequency to pass through, and suppresses all signals below the cut-off frequency. In a properly designed filter for the suppression of television interference the TV signals will pass through with negligible attenuation. Such filters are usually designed to cut off somewhere between 30 mc and the lowest TV channel. A number of good commercial filters are available. See Fig. 12-1 for specifications of a high-pass filter.

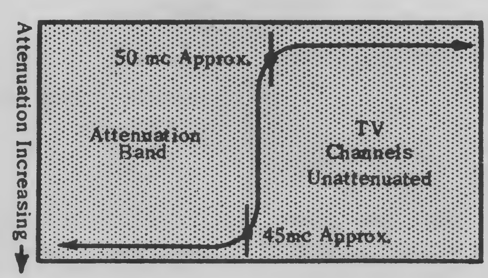
HIGH PASS FILTER FOR 300 OHM TELEVISION RECEIVER INPUT



C = 15 mmfd Ceramic

L_1, L_3 = 1.2 mh (21 Turns No. 24 Enamel Wire Close Wound on ¼" Diameter Polystyrene Rod)

L_2 = 0.6 mh (15 Turns No.24 Enamel Wire Close Wound on ¼" Diameter Polystyrene Rod)



Caution!

No. I Be certain to supply a good electrical ground with an absolute minimum of lead, preferably to set ground. Where receiver has AC/DC chassis, ground through 0.001 mfd, 600 Volt mica condenser.

2. Place filter as close as possible to r.f. input transformer.

Commercial filters are available in the following ranges both fixed and tunable

0-30 Mc 0-50 Mc 20-30 Mc 40-50 Mc 88-174 Mc

Fig. 12-1. High-pass filter. *Courtesy WTVIC.*

Cooperation by the Manufacturers in Eliminating Amateur TVI

Certain of the television manufacturers have indicated that, under certain conditions, they will provide high-pass filters to owners of TV receivers already sold by them, at no cost to the purchaser. If a serviceman, during a routine service call, finds by trial that a high-pass filter at the antenna input terminals of a receiver reduces or eliminates amateur TVI, or if it is otherwise determined that the TV receiver is at fault and a receiver overload condition exists, he should advise the customer accordingly and report the situation to the manufacturer's distributor or representative. It may be the policy of the manufacturer to provide and install an appropriate filter, free of charge.

Filters, to be most effective, should be mounted inside the TV receiver as close as possible to the r-f input transformer of the receiver. Filters mounted at the back of the set at the antenna terminals may help, but will not always eliminate pick-up of strong r-f signals.

If It Is Not the Policy of the Manufacturer to Provide Filters

If such a case is encountered where a high-pass filter is applicable, inform the set owner that he, and he alone, is obliged to purchase the equipment if he wishes to eliminate the interference. The viewer should also be informed that a high-pass filter improves the general reception by eliminating most of the noise and general interference as well as the local interference he objects to.

What Should You Do If the High-Pass Filter Is Not Applicable?

If a high-pass filter proves to be ineffective in cases of amateur interference, and if it is determined that the interference is caused by harmonics and is not due to the TV receiver design, it is recommended that you notify the local district office of the FCC.

B. Television Interference Aids

(Prepared by the Washington Television-Interference Committee in cooperation with RETMA and the FCC.)

TVI Causes, Effects, and Solutions

1. *Diathermy, industrial heaters, etc.*
Solution: High-pass filter, a-c line filter. If these measures are ineffective, contact owner of interfering equipment and recommend manufacturer be advised.

2. *Radiation from local oscillator of nearby TV and f-m broadcast receivers.*
Solution: Realignment of offending receiver, at a different frequency.

3. *Strong signals from nearby radio stations, in-*

cluding f-m broadcast, amateur, police, taxi, government, airways and military services.

Solution: Install high-pass filter, line filter, or in extreme cases, install an absorption filter tuned to the interfering signal. If these measures prove ineffective, locate and contact owner of equipment. (See Fig. 12-1.)

4. *Cross-modulation external to the receiver,* but possibly including external rectification sources such as corroded antenna and transmission-line connections.

Solution: Check lead-in or antenna for broken or corroded connections. Additional possibilities are poor connections in house wiring, plumbing, stovepipes.

5. *Multiple images*

Solution 1: Reorient or relocate antenna and/or lead-in.

Solution 2: May be caused by standing waves due to impedance mismatch between antenna, transmission line, and receiver impedance. This condition can be detected by wrapping a piece of metallized paper around lead-in, watching for variations in reflections and signal strength while sliding metallized paper along lead-in.

6. *Direct i-f pick-up*

Solution 1: Shield section responsible (shielding must be complete).

Solution 2: Realign i-f.

When a TV receiver is in a strong field of r-f close to the immediate frequency of the receiver, direct pick-up in one or more of the i-f stages is likely. For example, a signal on 21.9 mc would probably be picked up in the i-f of a TV receiver using a 21.9 mc audio i-f channel. If a high-pass filter is ineffective in eliminating the interference, the i-f should be realigned to a frequency different from the interfering signal by a few hundred kc (as an example, in this case, to 22.2 mc).

Solution 3: Check lead dress, particularly of long leads.

7. *Image interference* (This situation exists when a strong signal occurs at the oscillator frequency plus or minus the i-f.)

Solution: Use appropriate stub or tunable trap. (Refer to Fig. 12-2.) High-pass filter is ineffective in this specific application.

8. *Signal operating in normal receiver passband.*

Solution: Find offending source and, if unable to obtain cooperation, report to FCC.

9. *Misadjustment of i-f tuned circuits, or misadjustment of TV receiver controls* (traps may be faulty).

Solution: Correct misalignment, or replace or repair defective component.

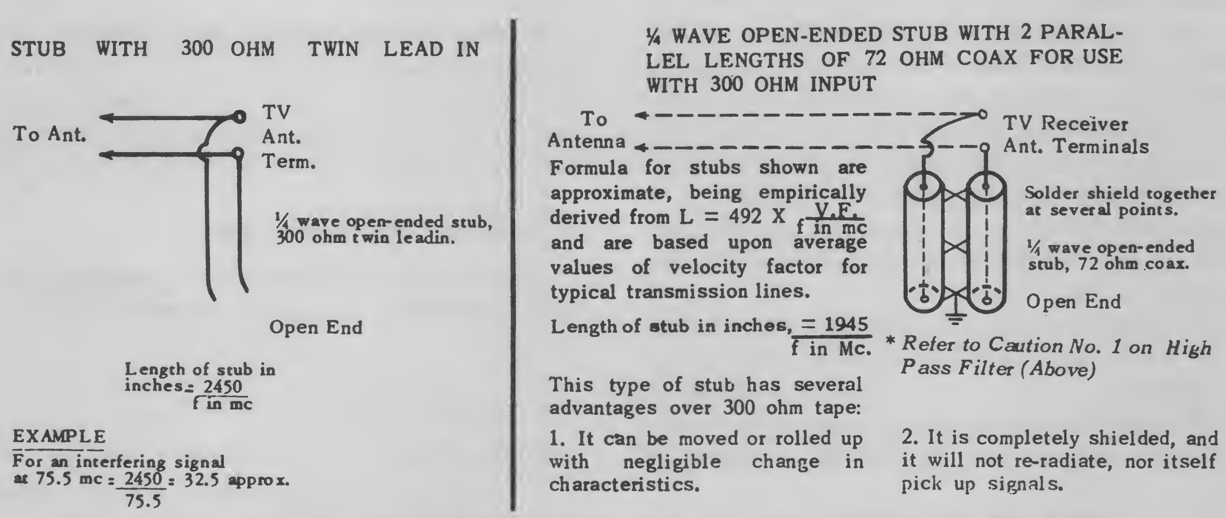


Table of lengths of 1/4 wave open, 300 ohm line covering the FM band:

Frequency in Mcs	L in inches
88	27.8"
95	25.8"
108	22.7"

Fig. 12-2. Constructing a stub to reduce TVI at a specific frequency. Courtesy WTVIC.

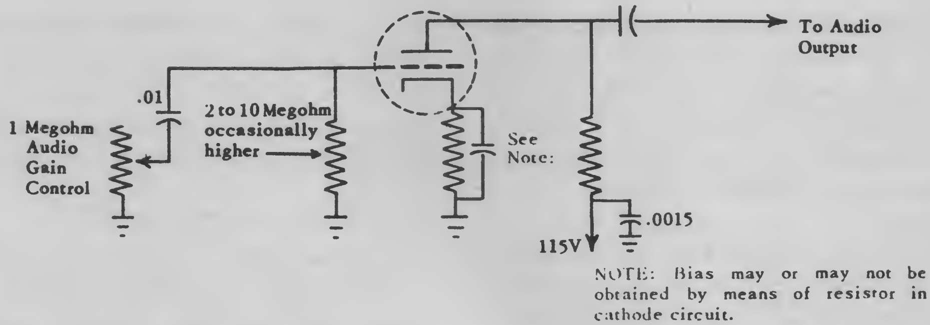


Fig. 12-3. First audio amplifier. Courtesy WTVIC.

10. *Faulty neutralization,* particularly in triode or in triode-connected pentode-cascode type tuners, may cause crosshatch pattern on picture tube.

Solution: Locate defective component and replace.

11. *Audio rectification characterized by audio from other than TV stations,* such as police broadcast, taxi, utility, amateur stations.

Characteristics and Identification of Rectification Effects

The grid circuit of the first audio stage of a TV receiver usually requires from a fraction of a volt to a few volts of bias. Any r-f signal from a nearby radio station (taxi, police, military, amateur or other) strong enough to overcome this small bias, or sufficient to cause rectification as a consequence of nonlinear grid voltage-plate current relation, will be rectified and, if amplitude modulated, will appear as an audio signal passing through the audio amplifier together with the audio signal of the station actually tuned to. An f-m or unmodulated carrier of moderate intensity may be observed as hum or distortion. A strong f-m or unmodulated carrier will reduce the audio output level of the station to which the receiver is tuned. If the interfering signal is keyed, program reception will follow with breaks in volume. This type of interference will be evident on all TV channels, regardless of receiver tuning adjustments.

To identify this type of interference, the output of the last i-f amplifier can be momentarily shorted through a capacitor to ground. If the interfering signal persists, it is most probably due to pick-up in the first audio amplifier, and the prescribed procedures are effective. If the interference discontinues, it is not pick-up in the audio stages but is probably due to intermodulation in the r-f or i-f stages.

These same effects can occur on a-m and f-m receivers, phono and public address amplifiers, hearing aids, and other high-gain audio devices.

Receiver Modifications

Effectively eliminating this type of interference depends entirely on preventing the r-f from being rectified, for once rectification occurs, it is impossible to separate or filter the interference from the desired signal.

To prevent rectification from occurring, steps should be taken to provide a low-impedance path for r-f between grid and cathode of the audio amplifier tube.

Figure 12-3 shows the usual first audio amplifier and indicates typical values of associated components.

Figure 12-4 (A) and (B) presents Fig. 12-3 modified to show changes necessary to eliminate this type of rectification.

The bypass capacitor shunting the tube input provides such a low impedance at i-f frequencies that it practically shorts out any r-f signals at this point, and the series choke or a resistor helps to prevent the r-f from reaching the grid. The choke arrangement gives best results, but the carbon resistor is almost as effective.

As in a-c/d-c type of standard broadcast receivers, bypassing the heater of a combined detector and first audio stage to ground, with a 0.01-mf capacitor, will often prove helpful. Be certain that screen and suppressor grid bypassing is adequate.

In extremely strong signal fields it may be necessary to filter the second audio amplifier, or output amplifier, in the same manner. Where the interference is strong enough to be feeding into stages after the first audio amplifier, care should be taken that no phase-inverter stage is affected by filter installation.

Series heater strings should be well bypassed to prevent the signal entering the tube through the heater leads. Both sides of the a-c line may be bypassed to the chassis with 0.01-mf to 0.1-mf (value noncritical) 600-v rated capacitors.

The tube shield, if used, should be checked for positive ground connection. If tube is unshielded, it may

be necessary to install a shield. Lead dress should be carefully checked. R-F pick-up may occur on long volume control leads running to the front of the chassis. Receiver wiring may represent an appreciable portion of a wavelength at the high frequencies and therefore pick up considerable r-f energy.

In isolated instances a volume control with ungrounded shaft may be found. Pick-up on the shaft, especially when the hand is placed on the gain control (as in adjusting volume), is considerable. The cure in this case is to install a control having a shaft insulated from the terminals, so that the shaft may be grounded to the chassis.

Dual- and triple-purpose tubes, when performing several functions (such as detector, first audio, and avc), present a special problem because of interelectrode capacitance and a common cathode which feeds from one circuit to another.

Where the usual remedies for preventing r-f rectification on the grid of a triple-purpose tube do not cure the condition, the audio section of the multiple circuitry may be removed and incorporated with a separate tube, preferably mounted on a small subassembly bracket under the chassis. The standard first audio circuit is then wired to the new subassembly, with the added resistor, bypass capacitor, and lower value grid leak incorporated as modifications in circuitry.

12. *Ignition (pulse) type of interference sources,* including electric motors and other power equipment, household appliances, thermostatic devices, and fluorescent or other lighting fixtures.

Solution: Line filters, change of location of antenna, or use of coaxial in place of flat line. If these measures do not correct the condition, locate the source and contact owner for his cooperation in eliminating the interference at the source.

"An Ounce of Prevention"

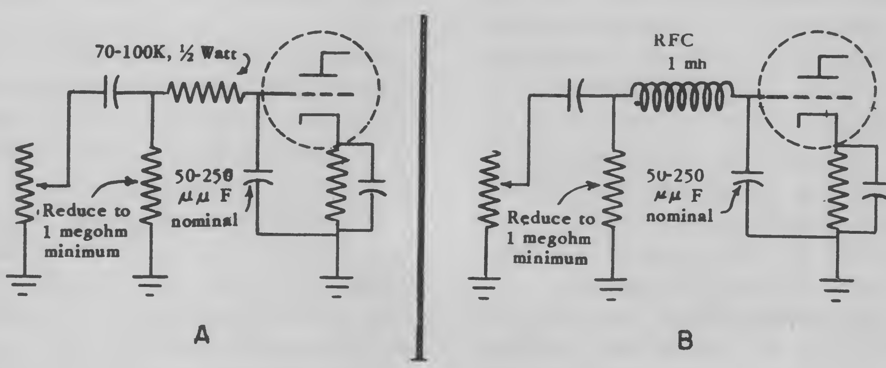
An unwanted r-f signal may get into the receiver audio circuits as a result of direct pick-up through inadequate shielding or tube input shielding, but more commonly this will be introduced through power line coupling or through the antenna and transmission line. Any measures taken to attenuate or prevent r-f energy other than the desired signal from entering the set at the antenna or other paths are helpful.

This can be accomplished in stubborn cases (where the interfering signal is introduced through the power source) by installing the necessary power line filter. Commercial plug-in line filters are available for this purpose and are particularly suitable where space is limited, as in compact a-c/d-c receivers. Bypass capacitors for r-f in the line may also be effective.

Figure 12-5 shows the basic elements of construction for a power line filter.

An appropriate filter may be installed as close as possible to the receiver antenna input transformer if the interference is entering by that path.

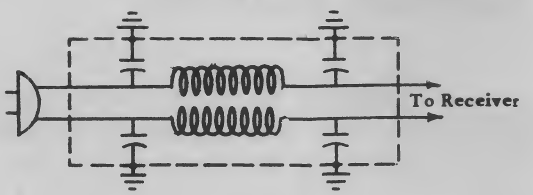
Essentially, the same cures outlined here also apply to audio systems other than those associated with standard broadcast and TV receivers.



NOTE: Where the value of the grid resistor is large it may be necessary to change the value of grid resistor to as low as 1 megohm. This will not appreciably affect the gain of the desired audio. However, care should be taken in choice of values for by-pass condenser and series resistor or inductance to maintain grid circuit preeminently resistive to audio frequencies.

Choke or resistor and condenser should be mounted directly at the grid pin of the tube socket with the shortest possible lead length between grid and cathode. For grid cap type tubes the grid lead should be shielded and the by-pass condenser connected as close to the grid cap as practicable.

Fig. 12-4. A-F amplifier modified to eliminate r-f rectification. *Courtesy WTVIC.*



Coils are 3" wound length of No. 18 enamel on ½" diameter form. Capacitors are 0.001 to 0.01 mfd, 600V rated, mica or ceramic.

NOTE: It is important that these filters be enclosed in a metallic shield to prevent direct pickup of signal, and the entire equipment should be carefully constructed electrically, with wire size appropriate to the load and effectively grounded either direct or through a 0.01 mfd, 600 volt rated condenser in the case of AC/DC sets with chassis which cannot be connected directly to ground. A water pipe or other plumbing is usually an effective ground.

Fig. 12-5. Power line filter. *Courtesy WTVIC.*

CHAPTER 13. CUSTOMER RELATIONS

Introduction

Career counseling today has become a major profession. Each year, thousands of students in colleges and universities sit down and have a heart-to-heart talk with people of experience and understanding. An attempt is made to appraise the possibility of success in the student's chosen field.

You may be interested in knowing one of the rules of thumb by which counselors try to evaluate the individual. First, the requirements of the job sought are analyzed. Then, the student is examined to determine whether he has the necessary qualities for success. Does the student have the desire to succeed in his job? Does he have the technical knowledge and skill that will enable him to succeed? And finally, is he sufficiently skilled in human relations requirements of the job?

For maximum success, none of the ingredients mentioned can be neglected. Any combination of one or two characteristics is not sufficient. All three must be present.

Let us examine these qualities to see why this is true.

Desire

To do a good job in any field, the individual must have a strong desire to succeed. His motivation must be more than just that of money. He must like his work. He must be willing to take the initiative in devising ways and means to do a better job. In simple words, the first ingredient in doing a good job is to *want to do a good job.*

This may sound very simple and obvious. But how many times have you seen men going around with an "I don't care" attitude? How many times have you yourself gone about your business in such a routine fashion that an impartial observer would wonder if you really were interested in your work?

At this stage of the game you should have a good measure of technical proficiency. It would be a shame to dilute this knowledge with an inadequate desire to do a good job. This desire, of course, is something no book or course can give you. It is mentioned here because it is such an important factor. Just remember this—if you do not like your work and don't really have a strong desire to do a good job, you will not succeed. Maybe you ought to get into another field.

Technical Knowledge and Skill

You can easily understand that without technical knowledge and skill it is impossible to get along in a technical vocation. The field of electronics is practically in its infancy, as measured by the long expanse of history. The opportunities for growth and expansion are limitless. But you must plan on continually enlarging your fund of knowledge if you are to share in the rewards of this industry of miracles.

In a way this is fortunate. It gets to be awfully dull if there aren't new things we can do and learn from time to time.

Human Relations

This is the third and most important landmark on the road to operating a successful business.

What do we mean by *human relations?* It is the sum total of the impressions we make when we deal with people. In its broad sense it refers to our relationships with our employees as well as our customers. In this discussion, however, we will narrow it down to customer relations.

Without smooth customer relations we cannot operate a successful business. Our customers will deal with us once and then drift away to others who know how to make their dealings more pleasant.

What can we learn about customer relations that can help us? Let us see first what makes us tick.

Relationship Between Technician and the Customer

The simple two-party relationship between a customer and technician is fraught with potential trouble. Each one brings to the situation his whole range of experience, knowledge, and emotional make-up When they require service, most people carry with them a certain amount of fear and distrust of the service technician; and it doesn't matter whether it is watch repair, automobile, plumbing, or TV repair that they need.

Customer Attitude

Customers will vary in many ways, depending on their maturity, financial condition, and education. The range will run from the troublesome customer, whose only object in life is to get something for nothing, to the other extreme, the one who doesn't care what you do so long as you fix the set and get on your way.

The average customer, though, will be somewhat understanding and reasonable, although not particularly glad that she *had* to call you.

Service, as far as the customer is concerned, is an expense which she can very well do without. She gets nothing new for her money. All she can say is that her set will work again. This only brings her back to

where she was before her set broke down. Obviously then, she can't be too happy about requiring service.

It's like going to a dentist. We know we have to, and that it may hurt, and that we'll feel better after it is all over—but that doesn't mean we like to go to a dentist.

So a service technician starts out with one strike against him. Insofar as the customer is concerned, he is a necessary evil. And, of course, the customer is concerned that he won't be too evil.

She worries whether the man she called will overcharge her. She remembers vaguely hearing about the "crooks" in the business. She wonders whether the technician knows what he is doing. She is afraid to let the set go out of her house because of what "they will do to it." She wonders if she bought a "lemon." After all, why did it go out of commission so early in its life? Or so many times in one year? Why does the technician need instruction books (schematics)? Doesn't he know my set?

Even when the charges are stated accurately and fairly, she wonders why they seem so high. "If the resistor costs only twenty cents, why do I have to pay $14.00 labor and pick-up charges?" she asks.

These are some of the attitudes the customer brings with her when she is face to face with the service technician.

Technician's Attitude

The technician has his own problems. Here again, we run the gamut of individual technical competence, desire, and ability to get along with people. At one end we have the untrained tube-puller, who thinks he knows more than he does. He found it so easy to collect five-dollar bills when he worked for someone else that he wanted some of this "easy money" for himself. So, he went into business for himself. At the other end, we have the electronic genius who can whiz a test probe around a chassis and come up with the lightning solution: "Your trouble is a flyback transformer, Madam. That will be $19.00, please."

The average technician falls in the middle of these two extremes. He is neither a wizard nor strictly a tube-puller. He does, on occasion, wonder about his ability to fix a certain set. Especially, when he is called upon to work on a type of receiver he has never seen before.

He wonders whether the customer will be able to detect this. He would like to charge fairly, but often has a dilemma in how to present a bill that will reflect his true labor costs without antagonizing the customer. He often resents the fact that he does not seem to have too much status as a professional. He gets mad when he sees so much publicity given to the few bad apples in the business. Despite all the cries about overcharges, he doesn't know any service technician who got rich in this business. Consciously or unconsciously, these thoughts affect him as he goes about his daily business.

Handling of the Situation

When we are aware of our feelings, we can usually cope with our problems a little better. If we assume that our description of the customer's feelings is correct, what is our best course of action?

What we should set out to do is to remove as many of the fears and sources of friction as is possible. This should be done from the very start of your relationship with the customer. Your first job will be to create an attitude of confidence on the part of the customer.

Creating Confidence

Customer confidence is usually the result of many little things. Let us assume that the customer has made her first contact with you in your place of business. Is the layout, equipment, and appearance of the shop attractive, neat, and efficient? It will be difficult for the customer to have confidence in you if her first reaction is that you don't have a clean, efficient place of business.

It doesn't take too much in the way of brush, paint, and elbow-grease to make a shop look attractive. Not to do this is bad business.

When the customer walks in, greet her cheerfully. If you have any problems, don't show them in your expression. Listen attentively while she tells you what is the matter with her TV set.

Then, before you take the job, try to dispel some of the fears in the customer's mind, even though they are not expressed. Have on display any certificate you may have received which will indicate adequate training, and some letters of commendation from your customers. Let her see the equipment you use in your work. Show her your complete file of service information which, you explain, is needed for efficient repair work.

Tell her that she will have an itemized receipt and that you will be glad to give her any of the defective parts you may replace.

You may have in your shop some attractive pictures of your wife and children (if you have any). A remark that you are anxious to please, that you have a home and a nice family (point to pictures) whose welfare depends on how well you satisfy your customers will do wonders in creating a friendly atmosphere.

Then, when you do take on the job, finish it thoroughly and promptly. Be sure you don't make any promises unless you intend to keep them.

Try, if possible, to repair the set in the home. No customer likes to see her set leave the house.

Use of the Telephone

Not always will the customer come into your store. Often, the first contact will be through the telephone. Here, then, is another opportunity to make friends, only this time it is through the telephone.

See that your phone is answered promptly. No one likes to do business with an organization that doesn't answer their phone when it rings.

When the telephone is answered, your voice should be pleasant and cheerful. "Good Morning, AGC Service, Jack Jones speaking. May I help you?" is a good way to open any telephone conversation.

It would be helpful for you to record your voice so that you can hear how you sound to others. It may be a shock to you. If so, try to put a little more "smile" into your speaking voice, particularly on the telephone. If you try to be cheerful, you will feel better and it will be reflected in your voice.

In summary, answer your telephone promptly. Don't keep customers waiting more than a minute; if you have to look up something, offer to call back. Watch your greeting, voice, expression, and choice of words.

The Home Call

How you conduct yourself in the customer's home will determine whether you will be a successful service technician. Learn to greet the customer by name.

Don't be afraid to smile. Show your identification card and wait to be invited in. If you are wearing overshoes, be sure they are removed before entering the house. Wipe your shoes on the door mat.

There is no need to get into personal conversation with the customer other than to learn what the trouble is. You should comment on the fine set she owns. If you have done work for other people in the neighborhood, mention the neighbor's name. This will help create confidence in your work. A customer likes to know that your services are being used locally. Explain how you arrive at your charges. If you have to remove her set to your shop, invite her down if she desires, to see it being worked on.

Go about your business in an authoritative manner. Use a drop cloth under your tools and tool kit. Be very careful about any lamps, tables, drapes, rugs, and other items of furniture. Make it evident to the customer, as you go about your business, that you take pride in your skill and workmanship.

A cardinal rule of good customer relations is that you must be clean and neat. Obvious, isn't it? But many a technician skips a shave and a clean shirt from time to time. The negative impression thus created lowers the standing of the entire service industry.

Don't "knock" your competitors or the manufacturers. You always lose ground when you throw mud. A good general rule is, "When you can't say something nice about others, it is better to say nothing at all."

Since the customer doesn't understand too much about TV circuitry, there is no point in trying to bolster your ego by spouting technical obscurities. Just because you know Ohm's law and the customer does not is no reason for you to feel superior.

When you finish your work, leave with a pleasant goodbye. Leave your business phone number handy so the customer will know where to reach you when she needs service again. A label with your name and phone number on pressure-sensitive tape does this job very well.

Follow-Up

Your business will never grow if you don't follow-up on your customers from time to time. Remind them you are in business, with post card reminders. Let the customer feel that you are still interested in her set. She will develop a healthy respect for you, and in a small way, for the service industry at large.

All this is important, because only through the cumulative efforts of many conscientious service technicians will the status of the technician rise in the eyes of the public.

Watch your customer relations. Your slips will show.

APPENDIX

Faulty Picture Tube Patterns

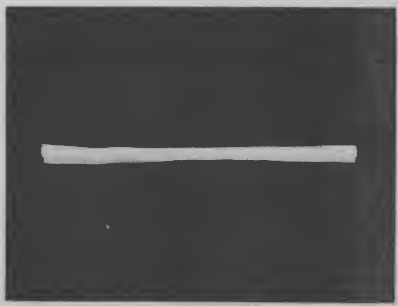
APPENDIX
FAULTY PICTURE TUBE PATTERNS

The following faulty picture tube patterns are reprinted from TELL-A-FAULT, a bimonthly service, and from TV TROUBLESHOOTING AND REPAIR GUIDEBOOK, Vol. 1 by R. G. Middleton, both published by John F. Rider Publisher, Inc.

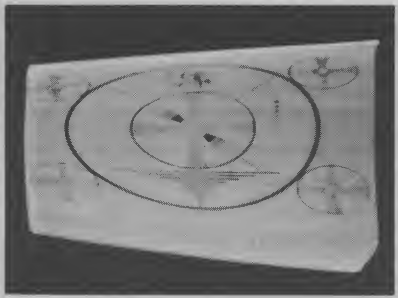
SWEEP CIRCUIT TROUBLES

REDUCED PICTURE HEIGHT
Leaky charge-discharge in output plate of Vertical Oscillator.

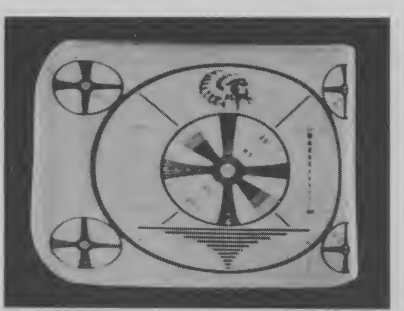
FOLDOVER
Leaky coupling capacitor to grid of Vertical Output Tube.



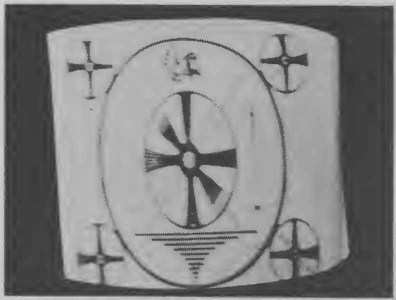
NO VERTICAL DEFLECTION
Open coupling capacitor to grid of Vertical Output Tube.



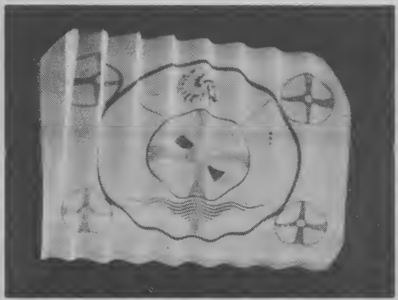
TRAPEZOIDAL PATTERN
Short across one of the vertical deflection windings.



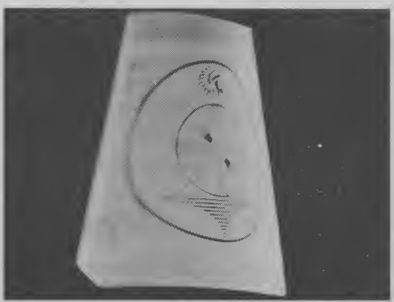
FOLDOVER
Leaky feedback capacitor from deflection yoke to grid of Horizontal Output Tube.



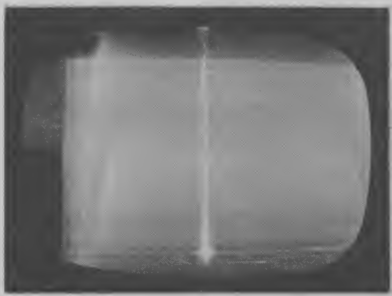
REDUCED PICTURE WIDTH
Leaky capacitor across width coil.



RASTER RINGING
Large increase in capacitance of balancing capacitor across one of the horizontal deflection windings in the yoke.

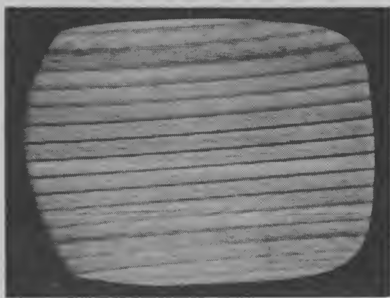


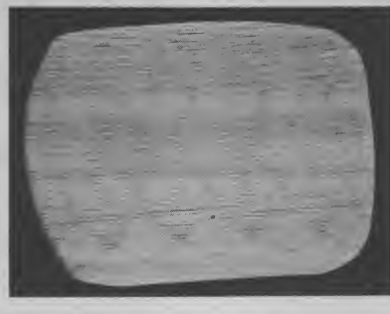
TRAPEZOIDAL PATTERN
Short across one of the horizontal deflection windings in the yoke.



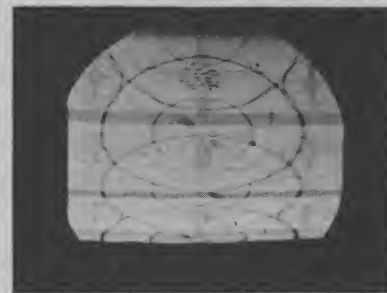
BRIGHT VERTICAL LINE AND UNSTABLE RASTER
Intermittent operation of horizontal oscillator.

SYNC CIRCUIT TROUBLES

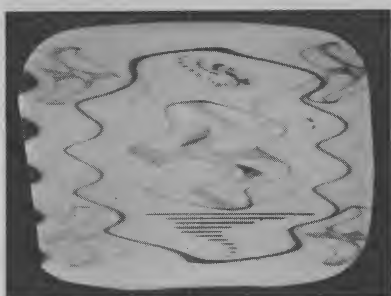




LOSS OF HORIZONTAL SYNC
Defective afc detector.

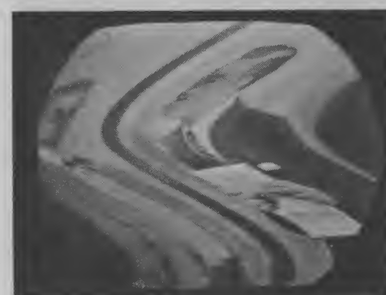


LOSS OF VERTICAL SYNC
Open resistor in Integrator Network.

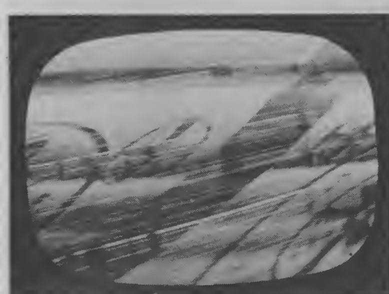


UNSTABLE PIE CRUST PATTERN
Shorted resistor in anti-hunt network, horizontal control circuit.

PICTURE PULLING
Video information in horizontal sync circuits.



PICTURE PULLING
Hum in sync circuits.



LOSS OF VERTICAL AND HORIZONTAL SYNC
Defective Sync Amplifier

VIDEO CIRCUIT TROUBLES

LOW PICTURE CONTRAST
Shorted i-f coil.

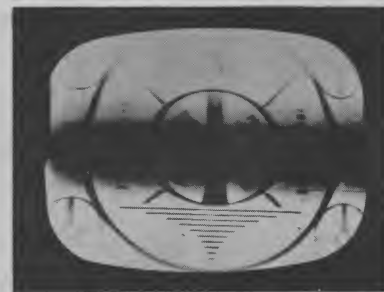
INSUFFICIENT BRIGHTNESS
Open return resistor in the cathode circuit of the picture tube.

SMEARED PICTURE
Defect in low frequency compensating network, plate of video amplifier.

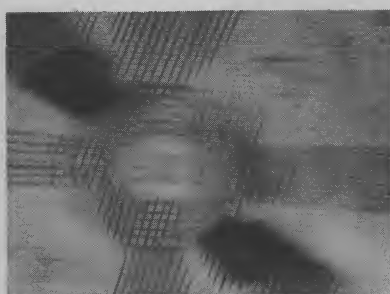
VIDEO CIRCUIT TROUBLES Cont'd.

GHOSTS AND PARTIALLY NEGATIVE PICTURE
I-f ringing.

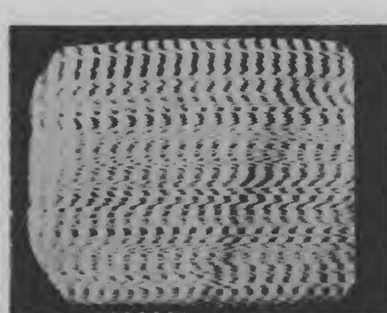
RINGING TRAVELS ALONG VERTICAL WEDGES OF TEST PATTERN AS FINE TUNING CONTROL IS VARIED
Highly peaked i-f curve.



HUM IN VIDEO
Filament to cathode leakage in video amplifier.



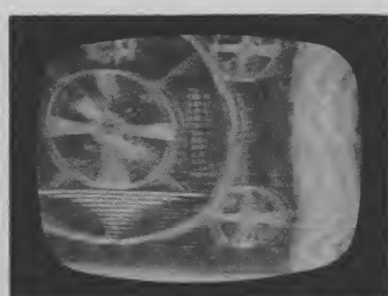
GRAINY PICTURE
Open 4.5 mc rejector trap in video amplifier.



OSCILLATING I-F AMPLIFIER

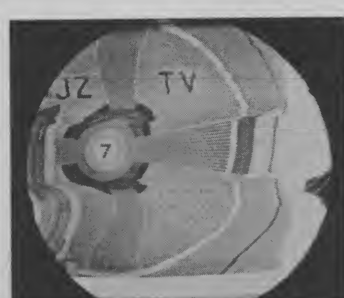
NEGATIVE PICTURE AND LOSS OF SYNC
Defective plate load resistor in Video Amplifier.

EXCESSIVE CONTRAST
Shorted agc filter capacitor.



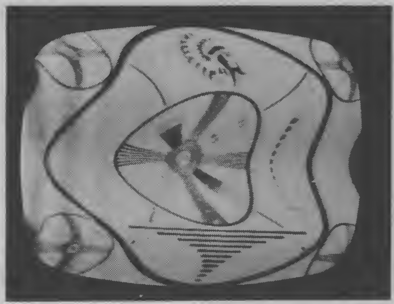
NEGATIVE PICTURE AND LOSS OF SYNC
Defective agc circuit.

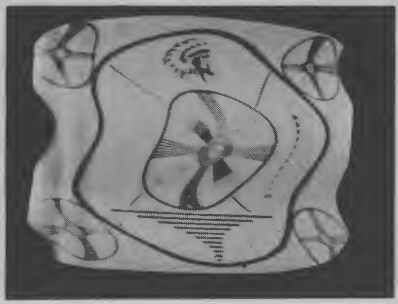
TRAILING REVERSAL
Defective resistor in agc diode.



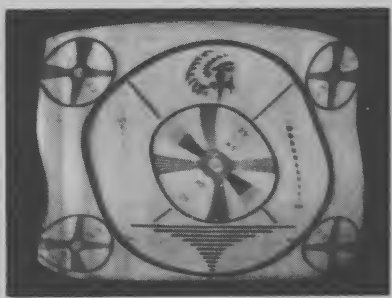
NEGATIVE PICTURE AND TEARING
Reversed video detector crystal.

POWER SUPPLY TROUBLES

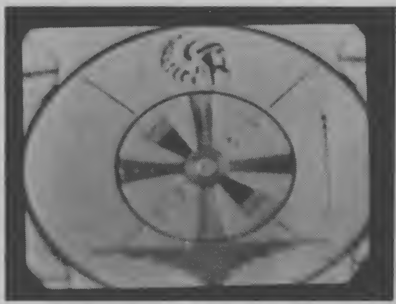




HUM
Shorted filter choke.

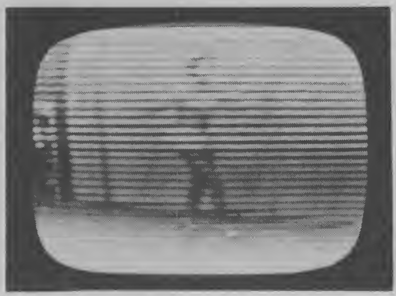


HUM AND LOSS OF BRIGHTNESS
Open input filter capacitor, B+ supply.

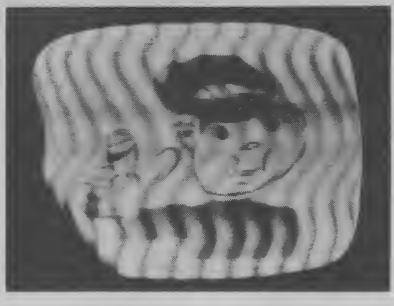


BLOOMING
(as evidenced by excessive picture size and poor focus)
Open doubler capacitor in high voltage supply.

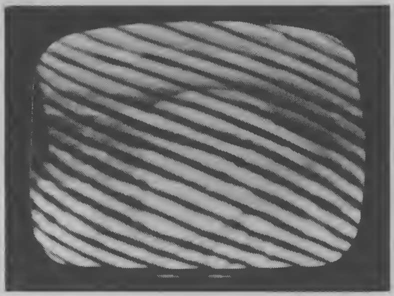
TELEVISION INTERFERENCE TROUBLES



SOUND BARS
2 kc signals.



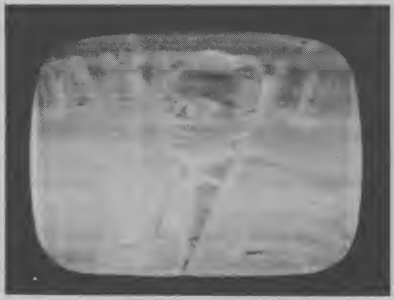
RF INTERFERENCE PATTERN



RF INTERFERENCE PATTERN

WINDSHIELD WIPER INTERFERENCE

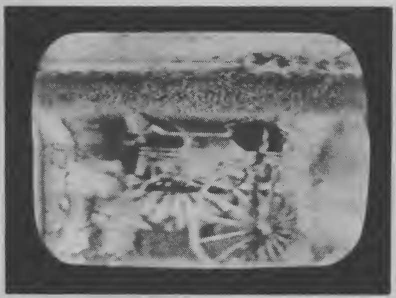
LOCAL OSCILLATOR RADIATION



NEGATIVE PICTURE PRODUCED BY INTERFERENCE

TELEVISION INTERFERENCE TROUBLES Cont'd.

NOISE (SNOW) IN PICTURE



INTERFERENCE CAUSED BY DIATHERMY

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